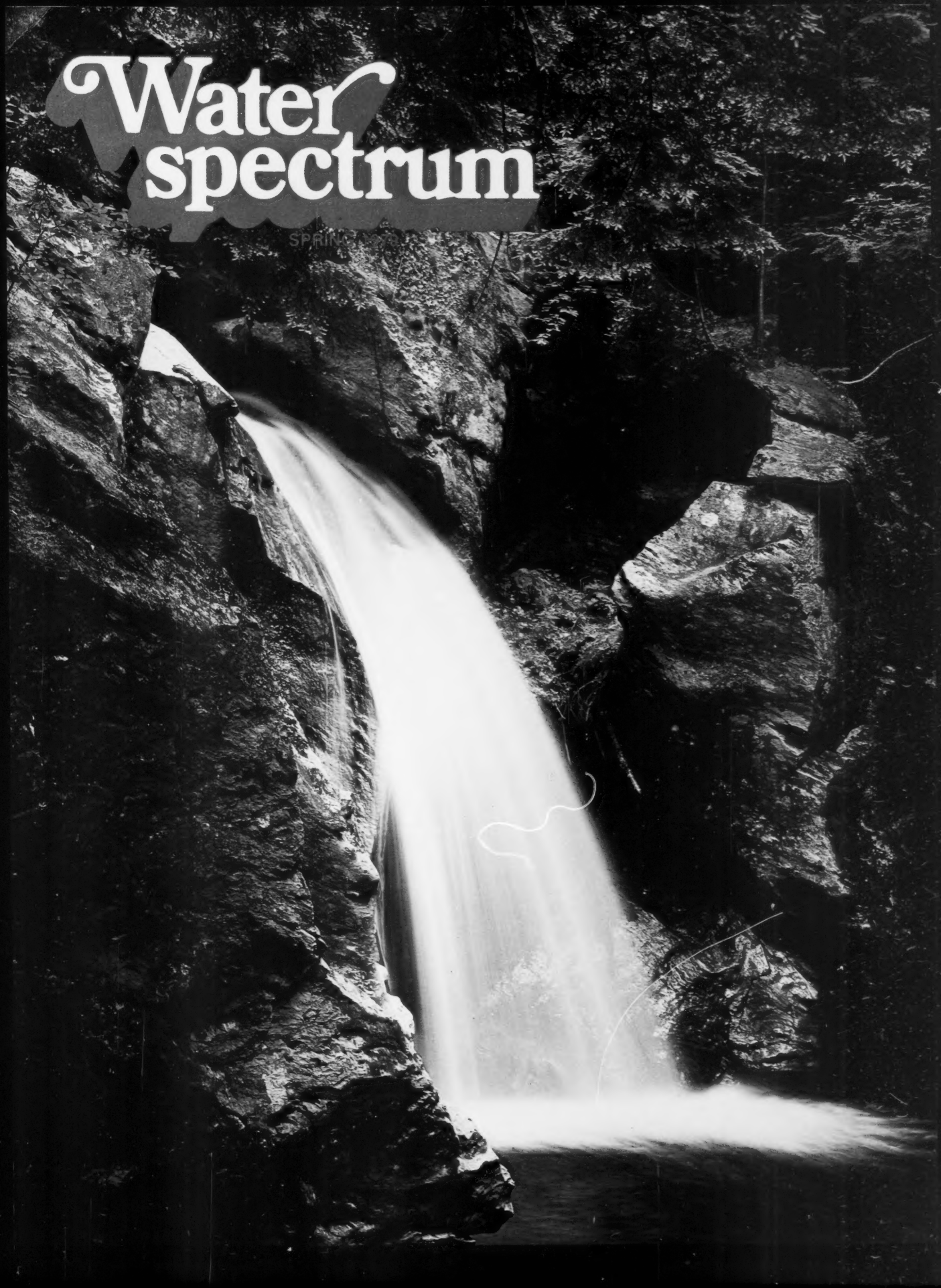
Water
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COVER: Bingham Falls near Stowe, Vermont.

(Photo by George A. Robinson)

Flash Flood Defenses

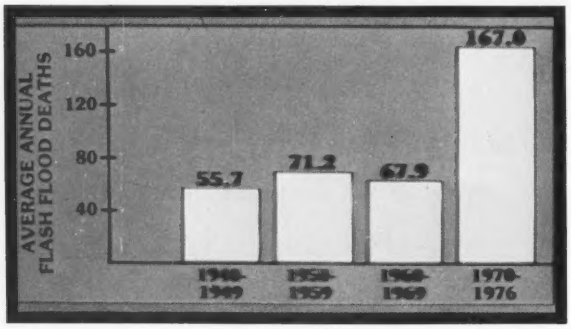
by Robert A. Maddox and Charles F. Chappell

Figure 2. Locations and societal impact of recent flash flood disasters.

During the 1970s flash floods have become one of the most significant natural disaster problems within the United States. Flash flood fatalities now exceed 160 annually, with the most dramatic increase occurring during the present decade (Fig. 1). Property damage, from all types of flooding, has also escalated rapidly with the annual loss now exceeding $1 billion.

The National Weather Service (NWS), a major agency of the National Oceanic and Atmospheric Administration (NOAA), defines a flash flood as one that follows the causative event (this might be excessive rains, a dam failure, etc.) within a few hours. The rise in runoff and stream levels is spectacular and produces hydrograph traces that reflect an extreme jump in discharge volume. Flash flood survivors often describe the devastating effects produced by the sudden "wall of water" and destruction within the flood region is often complete. The extent of recent flash flood disasters is indicated in Fig. 2. Since this figure was prepared, killer flash floods have also struck near Little Rock, Arkansas; New Orleans, Louisiana; Rochester, Minnesota; Palo Duro Canyon and Abilene, Texas; and Los Angeles, California. The problem is national in scope.

Figure 1. Average annual flash flood fatalities by decade.
(Figures courtesy of the Bull. Amer. Meteor. Soc., unless otherwise noted.)



Drs. Maddox and Chappell are meteorologists with the Atmospheric Physics and Chemistry Laboratory, National Oceanic and Atmospheric Administration (NOAA), in Boulder, Colorado.

Increases in death and destruction rates stem from a variety of reasons. The rapid spread of urban development often disrupts natural stream drainage patterns. In rural and mountainous areas, vacationers often visit flash flood prone recreational areas during the summer months—the time of maximum threat. People who live along "controlled" streams and drainages often have the attitude that "it can't happen here."

Recent floods in downtown Kansas City, New Orleans, and in Johnstown, Pennsylvania, have provided tragic proof that few areas are truly immune to the flash flood threat. The list of danger areas is increasing rapidly. More than 15,000 communities and recreational areas have been identified by the Federal Insurance Administration as flood hazard areas, and the Federal Disaster Assistance Administration reports that 85 percent of Presidential declarations of major disasters result from flash floods and/or general flooding. The town pictured in Fig. 3 (Idaho Springs, Colorado) is situated upon an alluvial fan and is obviously highly susceptible to flash flood damage. (The problem of alluvial fan flood hazards and land use control thereof was addressed in *Water Spectrum, Vol. 10, No. 1.*)

The growing realization of the severity of the flash flood problem has stimulated calls for preventive measures at all governmental levels. Many experts feel that effective responses to flash flood warnings could significantly reduce losses of life and property. The responsibility for dealing with the situation rests with a number of institutions—ranging from Congress and NOAA to state and local emergency preparedness agencies, on down to municipal planning and zoning boards. Beginning in Fiscal Year 1980, the NWS plans to implement a five-year program designed to develop improvements at all levels of responsibility.

The American Meteorological Society recently published a national statement of concern[1] that recommends a variety of actions be taken, to wit:

- Increase the capability to forecast the magnitude and location of excessive rainfall.
- Improve the ability to monitor and detect flash flood conditions.
- Plan and carry out an extensive and continuous public awareness program.
- Improve available information on the frequency of maximum precipitation and associated runoff for design and planning.
- Strengthen ties among meteorologists, hydrologists, engineers, social scientists, and action agencies in local communities.

The statement also emphasized: "Money and manpower are needed to accomplish these actions. The support and understanding of Congress, governors, mayors and local officials and the joint efforts of many Federal, state and local agencies are essential. The expertise and help of those in many disciplines—meteorologist, hydrologist, engineer, planner, behavioral scientist, educator, Civil Defense, law enforcement official—and the support of the news media are needed."

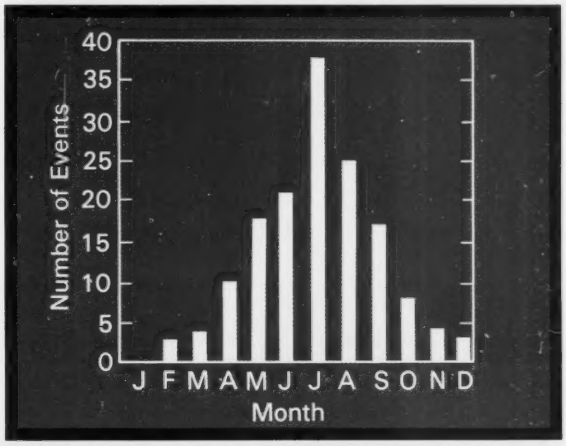
Some of the meteorological aspects of this serious national problem are considered in the following sections.

Prediction

The first step in an effective flash flood warning system must be the accurate determination of regions in which a potential exists (or is developing) for flash flood producing storms. This prediction phase should precede the onset of an actual event by a considerable time period (ideally three to six hours), so that state and local agencies can gear up to cope with the impending flood situation.

The NWS State Forecast Offices have the responsibility for monitoring meteorological conditions to determine if threatening situations are developing within their state. These offices use hydrological data provided by NWS River Forecast Centers to decide if expected rainfalls will be of great enough magnitude to produce serious flooding. If the State Forecast Office determines that a serious meteorological situation is developing, they provide special weather statements to state and local agencies and to the general public through the news media. If heavy rains appear imminent, a flash flood watch may be issued. The watch statement would identify a specific area in which the flash flood threat was great and would specify a valid time period of danger (usually 12 hours or less).

Figure 4. Monthly distribution of 151 flash flood events.



[1] American Meteorological Society, 1978: Flash floods—a national problem. *Bull. Amer. Meteor. Soc., 59,* No. 6, 585-586.

Figure 3. Idaho Springs, Colorado. (Photo by U.S. Geological Survey.)

The following are examples of statements issued to the general public prior to destructive flooding in the Kansas City, Missouri area:

"National Weather Service Kansas City, MO
430 PM CDT Mon. Sep 12 1977
Kansas City Metro Forecast
Severe thunderstorm watch till 8 PM this evening. Flash flood watch tonight. Otherwise . . . periods of showers and thunderstorms with locally heavy rain tonight.

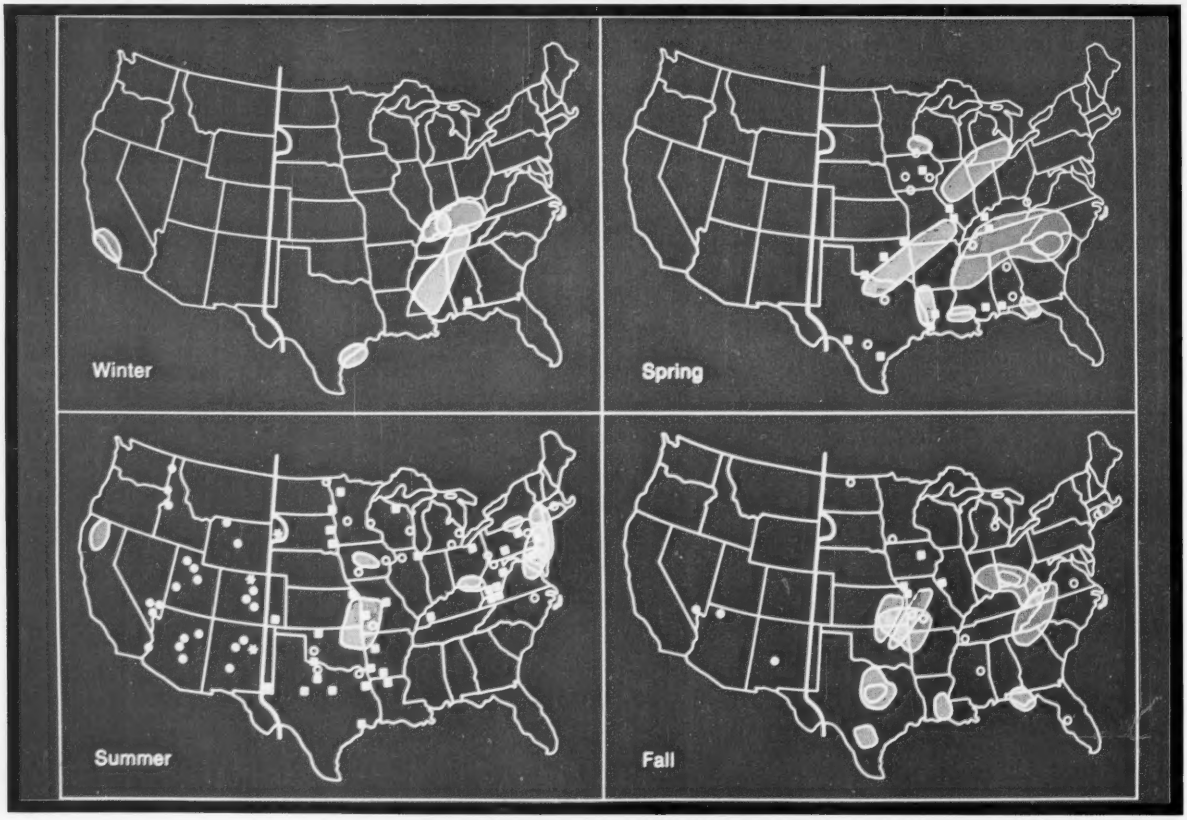
"845 PM CDT Mon. Sep 12 1977
Special Weather Statement
Very heavy rains have . . . moved into the Kansas City Metropolitan area. These latest rains are producing a very dangerous problem to motorists and persons in low lying areas. . . . Be prepared to move out quickly if the rains persist and streams begin to overflow. Do not take this situation lightly as it is potentially very dangerous to life and property."

The high level of concern over the flash flood problem has stimulated new meteorological studies of heavy rainfall events. A better understanding of the physical processes at work in these events is required, if they are to be more accurately predicted.

Figure 5. Geographical and seasonal (summer is June, July, August, etc.) distribution of 151 flash flood events.

Flash floods are most often associated with intense rainfalls produced by convective storms (thunderstorms and groups or systems of thunderstorms). Studies of a large number of flash flood episodes are enabling meteorologists to classify these events according to certain recurrent, common characteristics. Unfortunately, there are no specific criterion required in flash flood reports and the quality of descriptive information available for individual events varies considerably. Reports on times of occurrence are often vague, while specific details on the timing, duration and precipitation are sometimes totally lacking. In some cases this is due to occurrences in remote regions, while in other instances important details are simply not reported. An obvious need exists for initiating a national log of intense precipitation events.

A study of the meteorological aspects of more than 150 flash flood events, by the authors et al *(Bull. Amer. Meteor. Soc., 60,* No. 2), indicates that the majority of U.S. flash floods occur during the warm season, May through September (Fig. 4). The geographical distribution of flash floods by season indicates that in some parts of the country the threat is present year round (Fig. 5). Although events studied were reasonably well distributed across the country, regions that show few occurrences (such as Montana and Nebraska) are likely a result of sampling and/or reporting deficiencies. The area of the country that stretches from the Appalachian Mountains westward to the Missouri River Basin, then southwestward over eastern Oklahoma and Texas, experiences a large number of flash flood events.



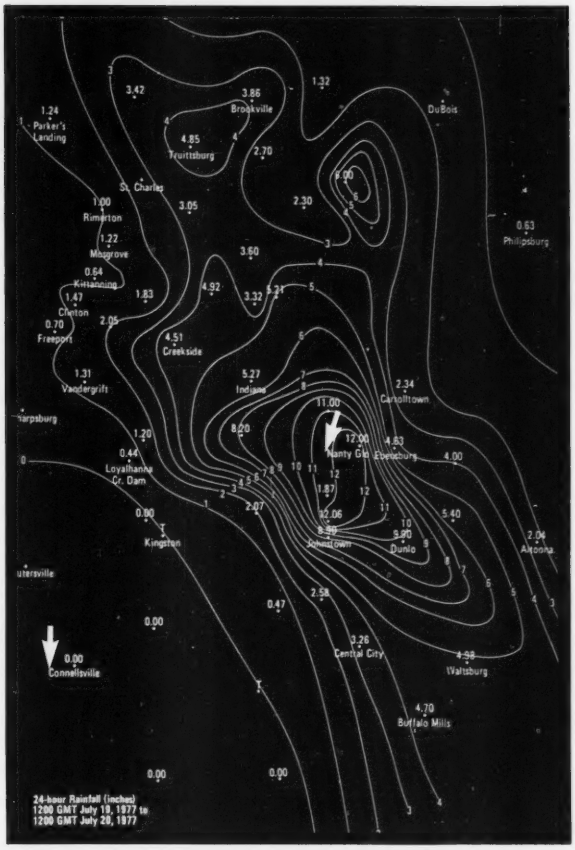


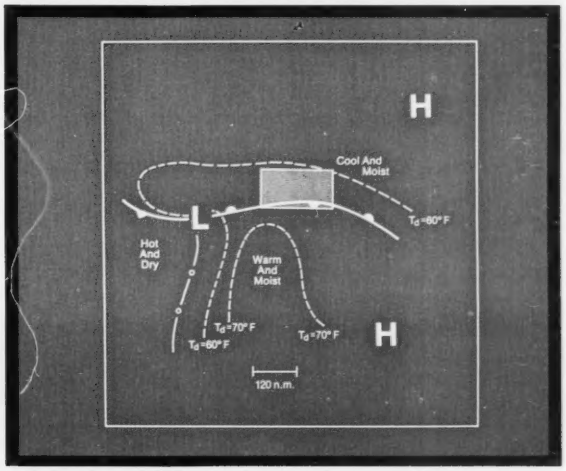
Figure 6. Rainfall amounts in western Pennsylvania that produced the Johnstown flood. (Courtesy of NOAA)

Late afternoon thunderstorm activity is often responsible for flash flooding in the western U.S.; however, over the eastern two-thirds of the country, a majority of flash floods occur in association with nighttime thunderstorms. This nocturnal characteristic of flash flood storms over the populous eastern portions of the country complicates an already difficult forecast and warning problem. If warnings are issued during late night or early morning hours their effectiveness is greatly diminished since only a small portion of the population is likely to be reached.

Flash floods in the eastern U.S. are almost always associated with rainfalls of more than four inches, and at least half of these events are caused by local rains of *more than ten inches*. The period of intense rain usually lasts for only a few hours, typically less than six. In contrast, flash floods in the western U.S. are often characterized by short duration (one to two hour), intense rainfalls of two to four inches. Rugged terrain often combines with the intense precipitation to produce very difficult warning situations because of the extreme flash nature of resultant floods.

The prediction problem is also complicated by the small area (mesoscale nature) affected by many intense precipitation events. Potentially damaging rains may fall over a region of less than 500 km^2 and might affect only a portion of a single drainage. An analysis of heavy rain amounts that fell in southwestern Pennsylvania during the night of July 19-20, 1977, in association with the destructive Johnstown flash flood, is demonstrative. The distance from Nanty Glo, where more than 12 inches of rain fell, to Connersville, where *no* precipitation was recorded, is only about 100 km (Fig. 6).

Figure 7. Generalized meteorological patterns associated with one type of flash flood event. Shaded region indicates area likely to experience heavy rains.



The study of a large sample of events has resulted in the recognition of generalized meteorological patterns that are conducive to flash flood producing rains. The surface weather pattern associated with a frontal type heavy precipitation event is one that occurs frequently over central and eastern portions of the country (Fig. 7). It is hoped that pattern recognition techniques will improve the short term forecasting of dangerous flash flood situations.

It is also important that meteorologists understand the physical processes that act and interact to cause specific storm cells to become highly efficient rain producers. Several highly detailed studies of specific events have increased our understanding of some of the important characteristics of intense rain storms. A physical model of the mature storm that flooded the Big Thompson Canyon in Colorado is shown in Fig. 8. This model was constructed from various types of meteorological information located after the event.

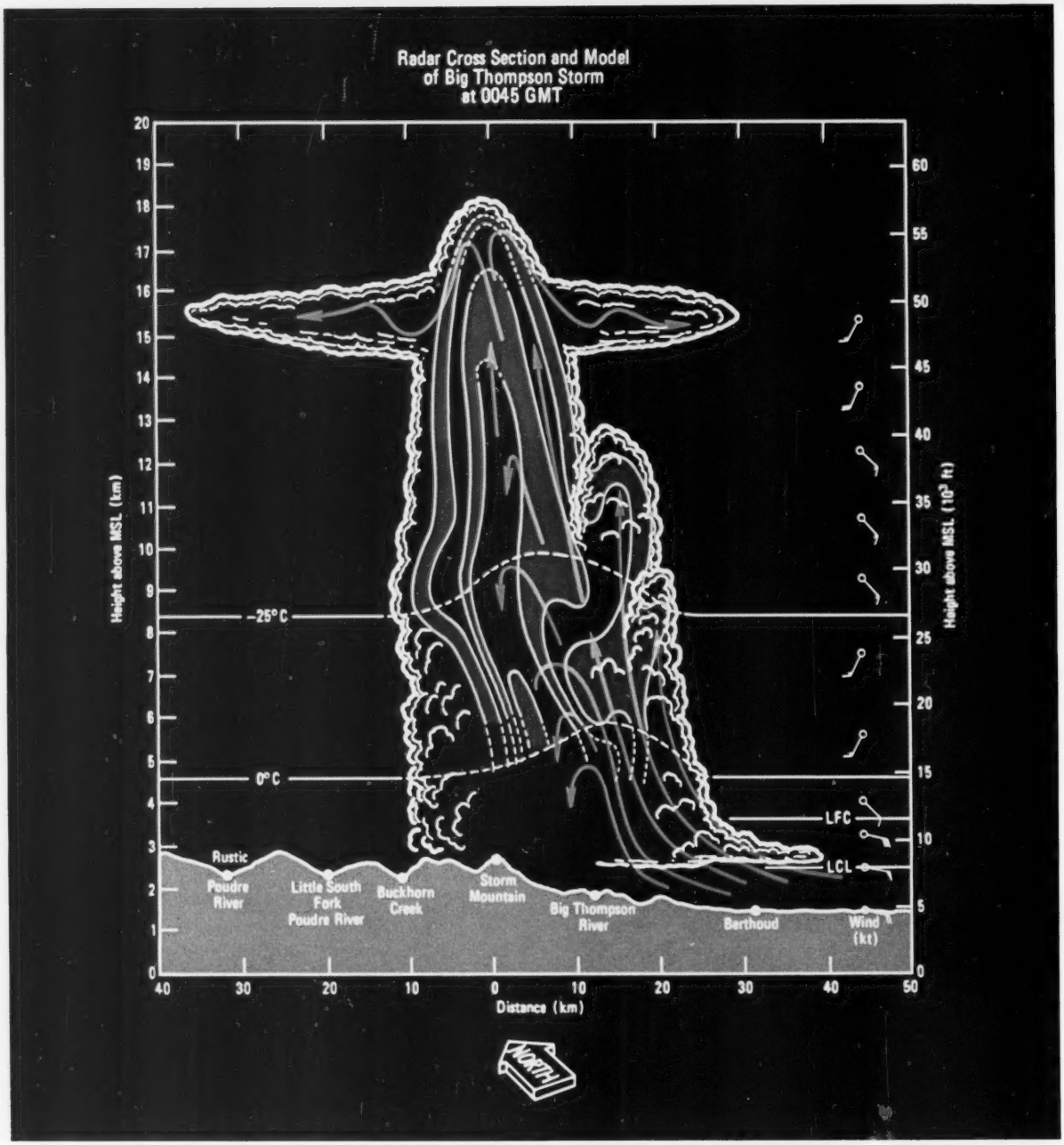


Figure 8. Cross-sectional model of the Big Thompson flash flood storm. (NOAA)

Detection

After a dangerous storm develops, the problem becomes one of determining if and where the heavy rains are falling. One of the simplest means a State Forecast Office has of detecting heavy rainfalls is through a cooperative spotter network. In such a system, volunteers and concerned agencies, such as the Highway Patrol, U.S. Forest Service, etc., relay information on current weather conditions to the NWS meteorologists. In addition to this type of network, there are a number of other technological systems that may provide valuable information to the State Forecast Office. It is important that such systems work efficiently under extreme conditions, because there is often very little time for the meteorologist to ponder the proper action. The rainfall that was measured at Dunlo, Pennsylvania, on the night of the Johnstown flood, showed that the two hours after midnight were most critical—more than four inches of the total precipitation fell in this short period (Fig. 9).

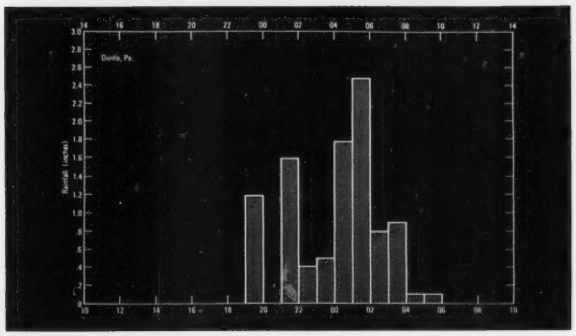
Observations from meteorological radars (the NWS operates a network of such radars that provides almost

complete coverage of the eastern two-thirds of the country and partial coverage of the West) can be of great use in determining the intensity and location of a heavy rain storm. The microwave power reflected from such a storm is compared to the transmitted power to estimate the rate at which precipitation is falling. Minicomputers can be used to process the data (Radar Digitizer and Processor Program) and provide estimates of accumulated rainfall. Once again, time is of crucial importance.

An estimate of how rainfall accumulated with time over portions of the Big Thompson drainage is shown in Fig. 10. These curves were developed from data taken by the NWS meteorological radar at Limon, Colorado, and indicated that at some locations the rain fell at a terrifying rate of more than six inches per hour. Radar data such as these can be used in conjunction with other meteorological information to help pinpoint flash flood trouble areas. Limon's radar echoes, superimposed on analyses of local wind fields and frontal positions, indicated that the heaviest rains were being focused in a narrow band along the Colorado foothills north of Boulder.

Many dangerous drainages have automatic rain and stream flow gauges that may be interrogated by the meteorologists and hydrologists at the State Forecast Office. Since these instruments are at fixed locations, they can provide valuable information only if heavy rains happen to occur over them and if they continue to function properly during extreme meteorological conditions.

Figure 9. Hourly precipitation at Dunlo, Pennsylvania, associated with the Johnstown flash flood. (NOAA)



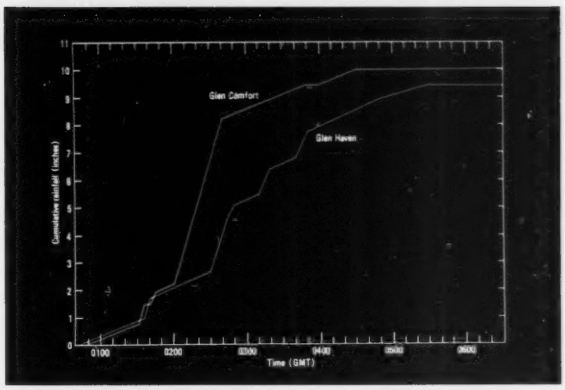


Figure 10. Accumulated rain amounts, estimated from radar data, in the Big Thompson Canyon. (NOAA)

Several NOAA meteorological satellites continuously monitor cloud conditions over the United States, and recent studies indicate that this data may be of use in detecting flash flood potential. This is especially true of infrared data which provides a measure of cloud top temperature. Very deep, heavily raining storms usually have intensely cold cloud tops. When such cold tops persist and linger over a given region, it is likely that heavy rains are accumulating. Infrared satellite data taken during the night of the Johnstown flood detected very cold cloud tops (Fig. 11. Light gray and white color levels indicate colder temperatures.) centered over western Pennsylvania. Man/machine interactive data processing systems are currently being developed that will allow satellite data to be analyzed, displayed and integrated with other important meteorological and hydrological information. Displays of digitized satellite infrared data (the cold cloud tops indicated by colored areas) can be mapped under geographical outlines of individual drainages (Fig. 12).

If a NWS office determines that a flash flood is occurring, or flood producing rainfalls are indicated by

radar, automated gauges, satellite data, or rainfall observers, a flash flood warning will be issued. This type of warning will cover a specific period of time, usually less than four hours. It may be valid for only a single drainage basin, although it is usually issued for an area encompassing several counties.

The following warning message was one of several issued the night of the Kansas City flood:

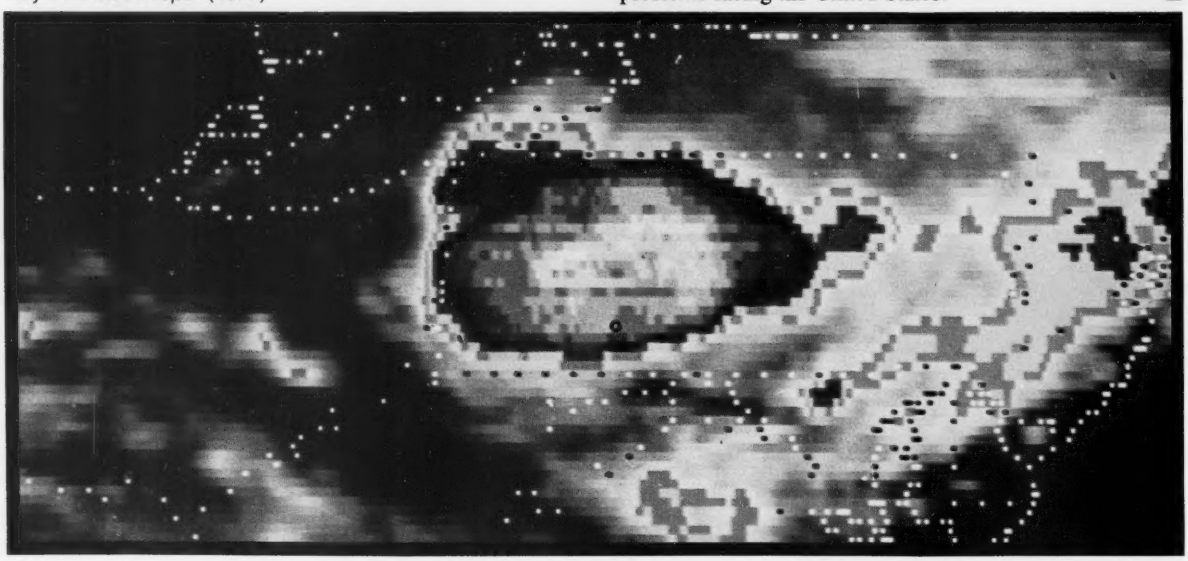
"National Weather Service Kansas City, MO
745 PM CDT Mon. Sep 12 1977
Bulletin
FLASH FLOOD WARNING
IMMEDIATE BROADCAST REQUESTED
The National Weather Service has issued a flash flood warning effective until midnight for persons in . . . Buchanan . . . Platte . . . Clinton . . . Clay . . . Jackson . . . Caldwell . . . and Ray Counties in Missouri. Heavy rain continues to develop across eastern Kansas and west central Missouri. Individual storms are moving up to the east while the area sinks slowly southward in eastern Kansas."

Once such a warning is issued the emphasis in the warning system shifts to more local levels. Some counties and/or communities may have developed little in the way of flash flood emergency systems, while others may be well prepared to deal with serious flooding. A number of vulnerable communities have installed automatic Flash Flood Alarm Systems (FFAS). These automated systems trigger an alarm, located in an appropriate local agency with 24-hour staffing, when critical stream levels are reached. During major flooding in the eastern U.S. in April 1977, FFAS's provided valuable information on critical river levels to several local NWS offices.

Figure 11. Infrared satellite photograph depicting a strong complex of storms over western Pennsylvania. Gray and white shading, within the darker shaded regions, indicates very cold cloud tops. (NOAA)

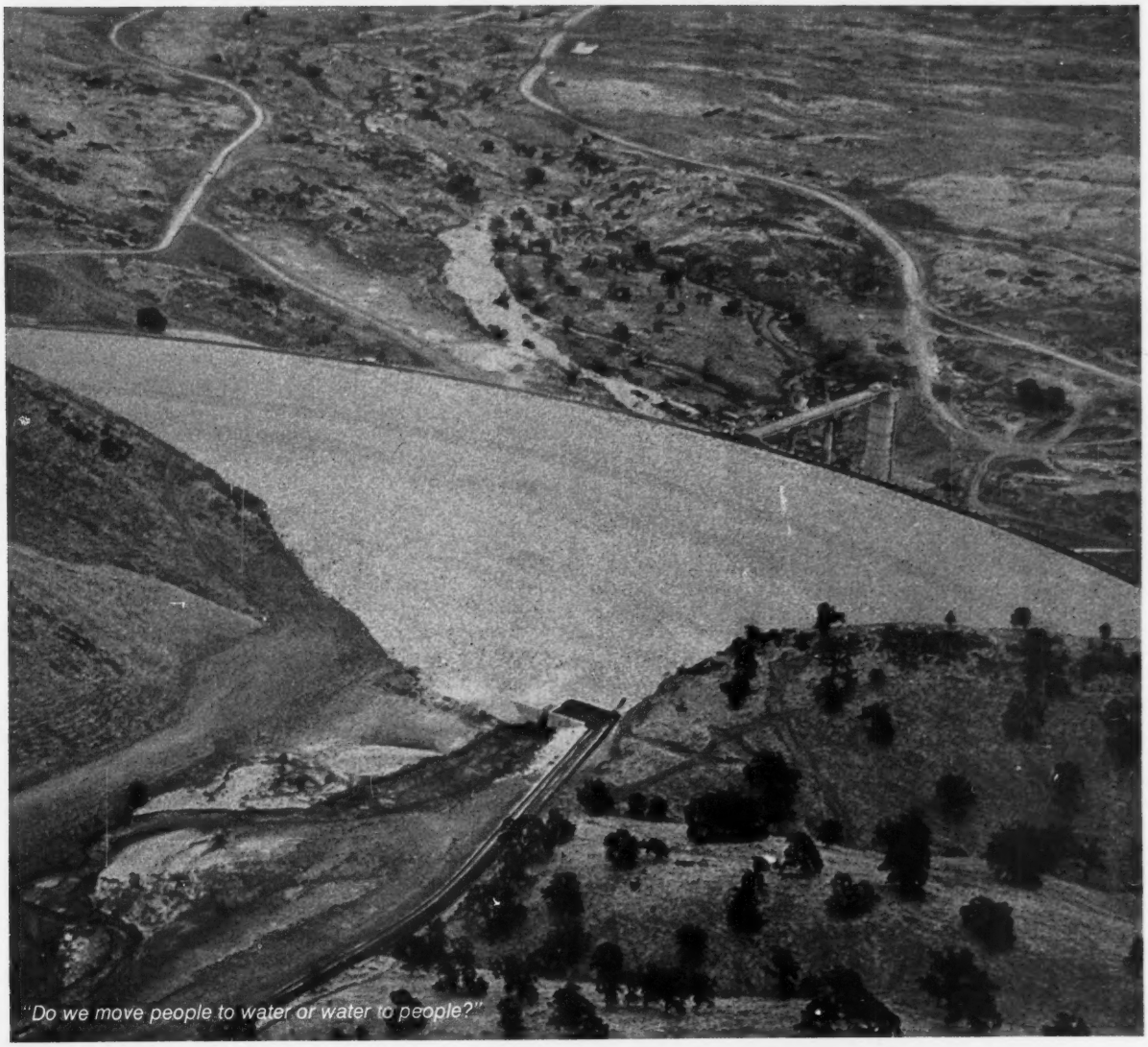
Figure 12. Satellite infrared data, color enhanced so that red areas represent the highest and coldest cloud tops, with drainage basin outlines mapped onto the field. Data was processed on the Colorado State University interactive data processing system. (Courtesy of D.E. Bielicki, Col. St. Univ.)

During the next decade, programs such as the flash flood effort being launched by the National Weather Service should achieve more unified deployments of technological resources into the flash flood watch/warning program. These efforts will eventually produce significant improvements in the prediction and detection of flash flood conditions. However, the problem is not simply one of developing meteorological understanding and better predictive techniques. If effective inroads are to be made into the societal impact of these events, coordinated efforts are required of many diverse disciplines and institutions—ranging from meteorology and hydrology to local Civil Defense agencies. The flash flood is truly one of the most complex natural disaster/environmental problems facing the United States. ■



FUTURE THINKING: FAD OR NECESSITY?

by Jerry Delli Priscoli



"Do we move people to water or water to people?"

For water resources planners "the times they are a-changing." Success is no longer measured by the traditional yardstick of new structures, but by the basic quality and availability of our water. Environmental regulations, embodied in a growing number of regulatory agencies, surround us. Planning for the operation and maintenance of present facilities has become as critical as planning for new projects.

Our guiding water resources laws and regulations ask us to project "without" and "with" project conditions. As if that isn't enough, we are told to "participate" with the public while we expand planning options. Are we water resources planners to become a new breed of democratic soothsayers or crystal ball gazers?

To the contrary, systematically thinking about the future has become deadly serious to our democratic institutions, engineering services and planning professions. Let me illustrate. Do we move people to water or water to people? Past projections show adequate per capita fresh water on a global level. But usable water is often not accessible to people. A good deal of development in western and eastern civilizations can be seen in the context of answering this question. Think about it. How are we answering the question—today and tomorrow?

In the upper midwestern United States we are talking about moving people away from water in flood plains. On the other hand, in the western United States, we hotly debate building further structures to bring water to people already settling far from it. Whatever the answer, as planners in the vitally important water resources arena we are part of that answer. The stakes are high but so are the opportunities.

Public opinion surveys continue to reflect Americans' reduced trust in our professions and institutions. As "bureaucrats" and "engineers" our esteem is low and is getting lower. But even as this questioning of our institutions increases, so too does the call for more and new types of participation in decisions. It is a great testimony to our faith in democratic processes that we vigorously question our institutions while looking to these democratic processes for answers.

Engineers and planners are at a nexus between the divergent faith in democracy and low institutional esteem. Traditionally, they provide critical services for man's ability to survive and adapt. Or, for man, as Jacob Brownoski describes him, as an "explorer" of nature . . . the only (animal) not locked into his environment." But this tradition quickly erodes when a society's engineering capability diverges from its changing social values. Water resources planners have a unique opportunity, indeed responsibility, to help realign our institutions to our democratic faith. This means starting by discovering what should be done rather than starting by positing what cannot be doae; moving beyond simply finding old solutions to old problems or even looking for new solutions to new problems. We must also creatively look for new solutions to old problems as well as to old solutions for new problems.

Dr. Delli Priscoli is a social scientist with the Institute for Water Resources, Fort Belvoir, Va., and currently Visiting Lecturer, Princeton University.

Beyond this lofty appeal, water resources managers have practical problems. Managers must plan projects that can be implemented in some reasonable time. But projects can be halted or altered in planning, implementing and even operating stages. This is the water resources manager's "real world." A manager can ignore such possibilities, since "whatever will be, will be." He can fight the problem, and either "blow the opposition out of the water" or be "blown out of the water." Or, a manager can find ways of anticipating and mitigating such conflicts. Whatever the choice, each choice reflects an approach to managing probabilities beyond pure engineering feasibility, in an uncertain social environment. Like it or not, that is the ball park in which water resources managers are playing.

In such a context this article addresses the question "why think about the future?" Specifically, the essay arrives at conclusions to that general question through discussion of these five questions:

- Is planning "predicting," or "creating" the future?
- What is the emerging role of the engineer in society?
- Is planning scientific-administration or political-legislation?
- What will thinking about the future do for us as managers?
- What is the meaning to society of how we anticipate the future?

Prediction or Creation?

What are the criteria of a good planner? Is a good planner one who makes a projection and somehow goes into hibernation for 20 years—only to return and find he is within five percent of an estimate. Or ten percent? Is the good planner one who can separate fact from fiction, or emotion from rationality? Science from politics? This or some variant is the oft-held view of planning. Often called an "instrumental" view, its results can be summed thusly: Planning must be limited to factual consideration of means toward ends which are established outside of the planning process.

The view is neat and comfortable but almost useless to field planners. Ask yourself how much time is spent coordinating and meeting with people outside the agency. Compare that to time spent bending over the design board. In most cases, more and more time is spent outside with various publics. Do our managerial rewards fit such a time allocation?

Simply put, we are part and parcel of that environment for which we plan. When we start planning, we interact with and change that planning environment. The planning itself becomes a change agent, and a degree of "interactive bias" sets into the planning process. As a result, planners can subtly cross the line from scientific prediction to self-fulfilling prophecy.

Social scientists have long recognized, and actual field experiences are now confirming, this observation. Consider for a moment population projections. When projecting small area population growth, any number—high or low—can become a political tool. A high number satisfies growth-oriented values; a low number, status quo and low growth values. You can spend time arguing about the numbers but negotiation over the number often merely reflects values and preferred futures held by the negotiators. Is the number negotiation forum the proper forum for developing consensus

"If they are flooded . . . who pays the bill?"

about future growth? Maybe. But it is likely to be played out in technical terms which may exclude interested and even influential parties from participation. We can agree on a number—call it a "prediction"—and defend it as scientifically objective. Increasingly, this will not work. If we are really thinking about the way things should be, perhaps the discussion format needs to be altered.

As we do more impact assessment and evaluation, people will become more attentive. They will listen to our projections. I think the Bureau of Reclamation's estimation of recharge rates in the summer of 1977 illustrates how closely planners interact with their planning environment. A lot of farmers reduced planting due to low ground water recharge predictions. When these predictions proved to be far too low, farmers became irate. How many incidents such as this does it take before an institution finds that nobody listens?

In one Corps of Engineer district, assessors armed with good technical engineering data started talking with people living near a reservoir take line.[1] Unfortunately, a local church was inside that line. Concerned local citizens began to protest and even boycott pro-reservoir businesses. Upon reexamination, the church did not fall under the take line. A mistake had been made. However, the new information was not believed and only enhanced the Corps' "devious" image.

Study after study of drought shows that the perception of drought—rather than less-than-minimum amounts of cubic feet per second or other technical measurement—determines public reactions. In the Northeast drought some years ago management of just such perception was the key issue. Low flow in Philadelphia raised the risk of salt encroachment in the water supply. Upstream releases raised the spectre of jeopardizing New York City for the sake of Philadelphia. To

[1]That boundary of a proposed impoundment inside of which all land is to be purchased prior to inundation.

the degree that drought had been "projected" as serious, this germ of conflict escalated. We have only to look at western water rights "wars" to see how nasty things can become. When such conflict occurs we have to ask ourselves, "what role did our projections or process of projecting play in the outcome?"

Often a strict instrumental view of planning can turn our well-meaning problem solving efforts into problem generating activities. Suppose, as has occurred, we are authorized to control urban flooding. As good planners, we talk to all concerned parties and develop a nice solution—channelizing through a blighted area, thereby ending the flooding and creating an aesthetic green space. Much to our surprise opposition mounts. The area is an urban, low income community. Crime rates are the chief area concerns. Our green belt is now viewed as providing the opportunity for more rape, theft and assault. In other words, our nice solution to a not so important problem has itself become a larger problem than the one we set out to solve. What happened?

Too narrow an instrumental view of planning allows us to look comfortably at only that which is simple, easy and familiar. However, what have we done to meet our "without project" and "with project" analysis? The same means-to-ends reasoning that limited us could also aid us, if only we had projected how our proposed ends could then be used as means to various ends by others.

If our planning activity does effect the planning milieu and we are, consciously or not, creating the future, what about the process by which we project? This begs the second question.

Scientific-Administration or Political-Legislation

Is planning politics or administration? This is no idle question. Planning and democracy often seem opposed. At least since the New Deal our political system has been attempting to synthesize these activities. Now there are almost as many definitions of politics as there are definers. One observer notes that "politics is the authoritative allocation of values." One of the best known contemporary definitions is "politics is who gets what, where and how." You notice what we are talking about—values, distribution of benefits, and future

"Compare . . . time spent bending over the design board . . ."

images. As planners, are we not also involved in such matters? Norton Long, a well known political scientist, sums up this thought:

> "The question is not whether planning will reflect politics, but whose politics will it reflect. . . ? Plans are in reality political programs . . . In the broad sense they represent political philosophies . . . ways of implementing different conceptions of the good life."

Frankly, those who are both receiving and not receiving the "what" are beginning to ask where and how decisions about their future are made. The secret is out; Pandora's box is once again open. People are questioning the "technical" in decisions, especially decisions that make projections about their futures. Planning decisions are more and more clearly perceived as effecting the distribution of values within society. In such a world can we explain our role purely as scientific-administration?

Often we refer to the "political" versus the "technical," or the "citizen" versus the "expert." Although the distinctions are useful, the gray area between these extremes increases.

People working within institutions make public policy decisions. A tenet of our democratic ideology is that governmental institutions provide opportunities for citizens to have a say in decisions which will affect their lives. In today's world, important decisions are made while carrying out activities we call "planning." Government planning activities are generally housed in administrative-bureaucratic agencies. Consequently, it is easy to see how planning can be viewed as primarily an administrative problem. But is it?

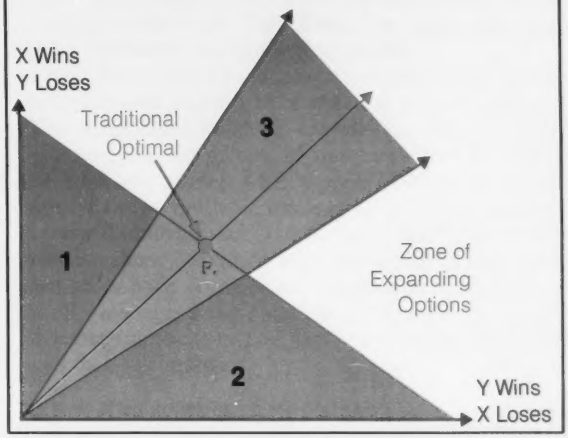
For example, reducing the risk of flood damage obviously involves a set of "rationally" thought out steps. A situation can be objectively studied, a structure proposed, engineering specifications established, and personnel requirements estimated. Certainly these technical operations require administrative and technical skill. But is there a risk if potentially flooded farmers don't perceive a risk? If not, and they are flooded, who pays the bill? Should a structure always be built? Should you propose an economical earth dam in a locality with a large cement industry? In short, does planning really assure public interest and welfare?

Over the years accountability and representativeness of the bureaucracy has been the focal point of much scholarly debate. If we are to help align important institutional resources to social values and needs, the accountability of those projecting the future is critical. Actually, broad scale future thinking is moving closer to our elected representatives. Look at Congresses' "alphabet-soup-scramble" for sovereignty over interpretation of the future. We now have CBO, OTA and GAO—all looking into the future and advising Congress.

We are moving away from making planners into politicians and more toward making politicians planners. We all know that elected officials often avoid raising unknown future issues which could upset the apple cart. However, projecting the future in an open forum—as planners are required to do—will increase the costs to elected officials of avoiding future projection formats. Non-involvement might even cost an election. The "layback and mousetrap the planner" syndrome will change. In making future projections, planners are forcing those with constituent accountability to "buy-in" early. That activism is good. It helps planners solve socially relevant problems in socially acceptable ways.

Although this sounds nice, will such open future projection increase conflict? The answer, I believe, is yes. But increased conflict can help crystallize issues. We are better off learning more about value impacts and issues early than late. Future projection can help us isolate extreme positions

Figure 1 **CONFLICT AND PLANNING**



and clarify negotiable intermediary positions. The clarification of issues and conflicts as other than extremes offers hope for finding new mechanisms of conflict resolution to supplement the old.

The fact that we so frequently ask the legal system to resolve conflict is testimony to our belief in rule of law. But that legal system is expensive and has limits. Like steel it is perfectly elastic until it breaks. When it snaps, it does so quickly and with little warning. Moreover, assuming before conflict arises that the legal system will be the primary mode of conflict resolution builds expensive conflict resolution into planning. If everybody knows they are going to court, the only way to play is to be "for" or "against." You can be sure that we will find those extremes. We can also be sure that those in the middle will either drop out or join an extreme. In short, the very system we believe so strongly in to resolve conflict, when misapplied, will end up generating more of that very conflict we wish to avoid. Open futures projection is a tool to help us avoid this dangerous syndrome. It helps expand and clarify that vast middle ground. For there is not one, but many possible futures.

What is the Planner's Emerging Role?

Given many possible futures, given the creation aspects of planning and given the value impact of planning decisions, planners obviously influence which future society follows. In this light, we can use our expertise purely to limit options and to conform with comfortable, timeworn solutions. On the other hand, we can also use expertise to ge nerate new options to meet changing social values. The first approach is heavily negative. The second is positive and much closer to the spirit of the planning profession.

Figure 1 characterizes a simple two actor planning situation. Often our view of the planner's role is to negotiate close to point P; that is, to find an equilibrium among X and Y losses and gains. The further our plans move into Zones 1 and 2 the more "political" and difficult they become to implement.

Zone 3 characterizes another view of the planner's role; that is, creating options and expanding horizons. In this view, we try to increase the wins for both X and Y. Indeed, our legal and regulatory requirements for anticipatory think-

"Litigation over a single lock and dam complex on the Mississippi has already cost $4 million . . ."

ing ask us to publicly clarify and define this zone. But defining Zone 3 is more than scientific prediction. It is helping society think about what should be and could be, not just what "must be."

Thinking of social "shoulds" and "coulds" does not simply mean projection from a current base year into the future. Too often we march into the future as if all problems are new and all history begins today. There are untold lessons about our possible futures yet to be discovered in our past. We would be well to consider more seriously the time-worn saying "past is prologue." Indeed, discovering the past can help build the strong collection identity we need to cope with the burdens of responsible futures "creation."

How to supply water to large populations, while protecting that population from floods, has been central to ancient civilizations from China to Africa, Europe and North America. Herodotus, the Greek "father of history" ascribes the beginnings of Egyptian geometry to the need for annually measuring inundated land. Whether in the Nile or Mesopotamia, the pioneers of large scale hydrologic works tried to link the sciences of astronomy and mathematics. Doesn't this sound curiously similar to current attempts at correlating weather projection and climate changes with flooding?

In his classic study of Oriental Despotism, Karl Wittfogel illustrates how man's effort to supply water to large populations can result in autocratic political systems. An ancient Chinese book of statecraft talks of special officials who control irrigation water from reservoirs. In ancient Persia, the King himself supervised discharge and release operations. So, part of the water resources planner's "expanding-options" role is also facilitating collective discovery of past man-water relationships.

What Will Thinking About the Future Do For Us as Managers?

Operating in an environment of changing social values, conflicts over water resources use will increase. As water resources managers we must increase our conflict management skills. This entails anticipating and mitigating conflicts, involving people and facilitating consensus along the way. Failure to hone such skills will increase planning and operating costs, decrease responsiveness to public needs and weaken our nation. The trends are already unfolding.

The personal costs of family and town relocations out of hazardous floodplains have risen dramatically since the 1940s. Litigation over a single lock and dam complex on the Mississippi has already cost $4 million and the resulting rewrite of the affected environmental impact statement another ¾ million. Such expenditures help no one. They overload and choke the legal system and even challenge its legitimacy. Real water resource problems are not addressed, much less solved. Our institutions lose credibility. People perceive that at best, institutions inefficiently deliver unneeded products.

Things can be different. Low cost, early institutional analysis provides planners with organized information about feasible alternatives at roughly 1/10th previous costs for such information. Well thought out projections of construction impacts on the Chief Joseph Dam in Washington have pioneered new relations between state and Federal agencies. Successful mitigation programs to cope with construction impacts were designed and a new school to handle increased enrollment was built. The efforts were reasonably priced, well coordinated and had definable ends.

As water resources planners, providing public services, we have a responsibility to be effective. How do we know if those alternatives which we consider are implementable?

If we spend 80 percent of study resources on unimplementable alternatives, what happens? Do we ask for more money? Do we finish the whole study with 20 percent of the funds and strain the staff? Or, do we use the 20 percent to sell what we already have? As we all know, the closing costs of such sales have skyrocketed. We need to consciously and openly manage these questions. Systematically thinking about the future can help us answer these questions and deal with their uncertainties.

How often do we calculate our own professional benefits-cost ratio? Is our problem solving versus problem creating ratio in balance? The increasing demands for social mitigation programs imply that we have room to improve. Thinking about the future provides insight to this professional ratio. It can help us avoid the necessity of social mitigation and to do it effectively when necessary.

Future thinking can also help us budget. Rationally, we would like to increase study expenditures as we come to more clearly understand study problems and needs. However, we often do the opposite. For example, how often do we start by letting large contracts which result in excessive data collection with little focus on analysis? Thinking about the future can be a vehicle by which study team members develop a shared definition of study needs and problems. That shared definition can provide the base on which to develop a strategy for study expenditure.

Since thinking about the future draws in people from different backgrounds and roles it can force new energy into planning. People who rarely interact in their daily business might start. By sharing internal expertise, our manpower efficiency can be increased. So thinking about the future is not just crystal ball gazing or predicting events. It is creating, designing and expanding options. It is internal team building as well as external consensus building. It is a management strategy as well as "scientific" analysis.

Meaning to Society

Early in this century, the scientist-theologian Pierre Teilhard de Chardin perceptively noted: "The whole future of earth . . . depends on the awakening of our faith in the future." As water resources managers, we have much to say about whether that belief "in" and hope "for" the future is rekindled.

We are custodians of a great national resource; that is, a water resources organization that can get things done. We are custodians, also, of a great ideal: That people can and should have a say in those things that will effect their lives. We can contribute to matching our institutional service to democratic beliefs; to matching engineering capabilities to social needs and values. As water resources planners, our role can be pivotal. Congress, in the wisdom of recent water resources statutes, has given us the tools. How will we respond? ■

Lake Ontario Regulation

by William P. Erdle

Tourists at Niagara Falls are often amazed at the volume of water that passes over that world famous cataract. For most it is hard to conceive of 100,000 cubic feet flowing over the falls each second. Yet that is only about half the water that flows into Lake Ontario with each tick of the clock. Another hundred thousand or more flow into the lake each second through the Canadian Welland Canal, the massive U.S. and Canadian hydropower structures in the Niagara River, and from Lake Ontario's own tributary basin.

In fact, although Lake Ontario has the smallest surface area of any of the Great Lakes, essentially all the water that drains from the four upper Great Lakes eventually ends up there. (Together, the Great Lakes contain nearly one-fifth of the world's liquid fresh water.)

From Lake Ontario, the water courses east more than 500 miles through the St. Lawrence River to the Gulf of St. Lawrence and finally to the Atlantic Ocean. The St. Lawrence River, with its relatively narrow channels and populated shoreline, reflects any variation in Lake Ontario levels and discharges. There is a limit to the flow which can be carried by the river without damage, and any regulation of Lake Ontario's levels must necessarily take these limits into consideration. The limits result in constraints on the amount of discharge which can be released from the lake under a regulation plan.

The level of Lake Ontario rises or falls almost constantly. And with it go beneficial or deterimental effects on such diverse interests as shoreline property and recreational boat owners, commercial shipping, and hydropower production.

Extremely low levels, resulting from low basin runoff, place hundreds of docks and recreational craft in shallow water or on dry land, effect critical wetland areas, and can uncover the intakes for public or private water supply systems. Low levels can mean critical losses to the multi-billion dollar commercial shipping industry and the industries it serves. They can cause reductions in

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hydroelectric power generation equivalent to thousands of barrels of oil per day.

On the other hand, extremely high lake levels, when coupled with high winds or storms, can cause disastrous shoreline flooding and millions of dollars of erosion damage to structures and property. They can also mean water must be wasted and diverted from the hydropower plants; since the giant turbines cannot accept the resulting excess outflows, a portion must be "spilled." The extremely high velocities created in discharging unusually large volumes of water present navigation hazards. Because of certain hydraulic principles, high flows may even draw down the water levels of certain areas in the St. Lawrence River.

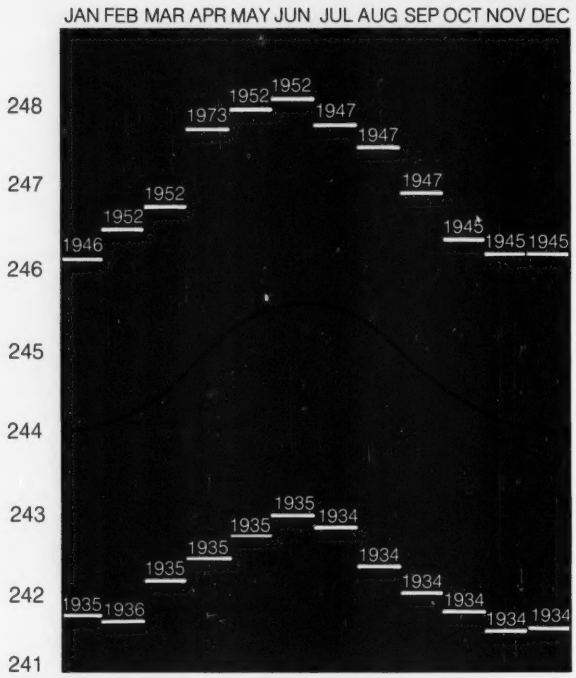
It might appear to be ideal if the levels of Lake Ontario could be regulated absolutely, but the vagaries of nature and the physical characteristics of the system make that impossible. Further, because of the conflicting nature of riparian interests, even complete control would not necessarily satisfy all of them.

This article hopes to explain the history of man's attempts to regulate Lake Ontario and the complexities of developing a plan which fairly distributes the benefits of regulation among riparian, shipping, and power interests.

Who Regulates the Lake?

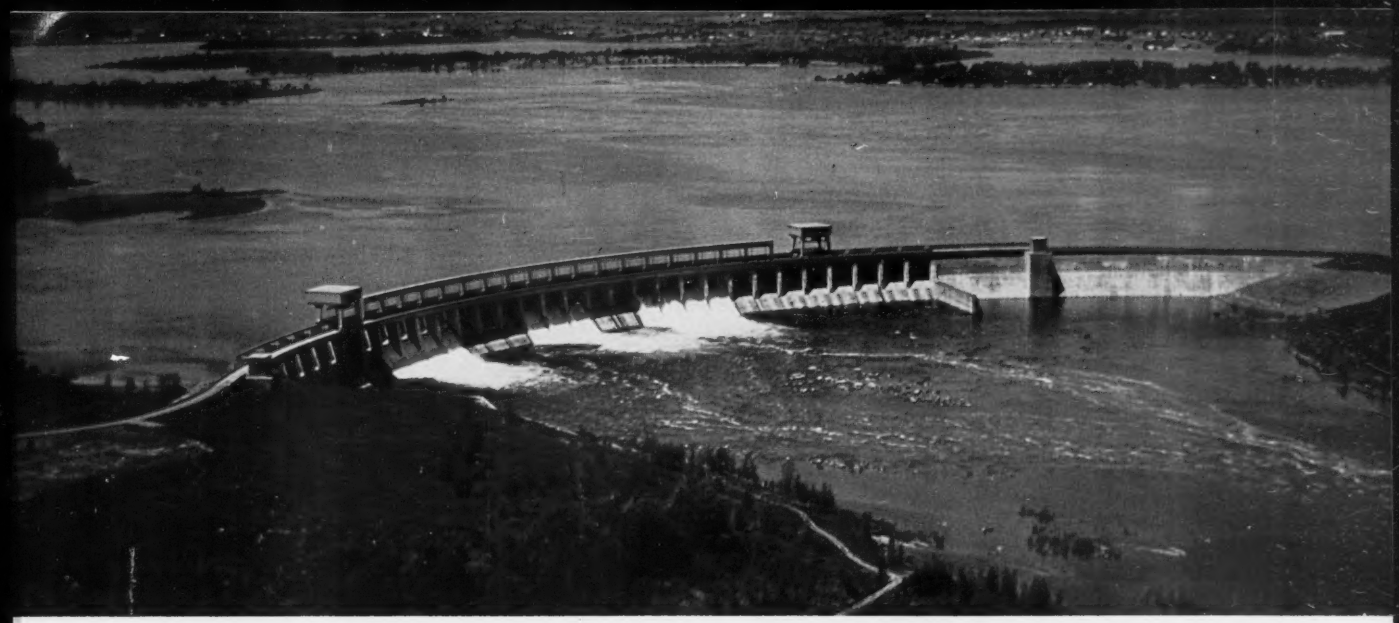
Prior to the 1950s Lake Ontario was regulated only by nature. Its levels depended primarily upon the precipitation on its local drainage basin as well as that on the basins of all the upper Great Lakes, and on other natural phenomena such as evaporation. The outflows through the then undeveloped St. Lawrence River were relatively stable because of the river's physical discharge capacity, but the total inflow from the upper lakes and Lake Ontario's own basin fluctuated greatly from year to year. Thus, the lake's level fluctuated dramatically.

To a great extent the lake remains regulated primarily by nature since she still determines the inflows. The construction of the St. Lawrence Seaway and Power Development Project in the 1950s, however, did give man some control of the outflows from the system.



This chart indicates (in black) the average annual cycle of Lake Ontario based on the period 1900-1977. Record high and low monthly levels and the years in which they occurred are in white. Note that with the exception of April all maximums were established in preproject years. This contrasts with Lake Erie where all maximums were established during the 1970s, and Michigan-Huron and Superior where the 70s set new records for 10 and 5 months of the year, respectively. Without regulation Lake Ontario would have set new record highs during the 70s for every month of the year.

Since 1909 the United States and Canada (then a dominion of Great Britain) have had a treaty concerning the boundary waters between the two countries. That Treaty established the International Joint Commission (IJC) to deal with all matters affecting the levels and flows of all waters shared internationally by the U.S. and its northern neighbor.



In 1973, 1974 and 1976 it was necessary to "spill" water through Long Sault Dam, a rarely used safety valve. This spillage, plus the flow through the Moses-Saunders hydroturbines, averaged 350,000 cfs during June and July 1973, or about 40,000 cfs more than the highest monthly Lake Ontario outflow during preproject years. (CoE photos, unless otherwise noted.)

Thus, when the two governments decided nearly 30 years ago to build the St. Lawrence Seaway and Power Development Project, the IJC included in its approval of the project several criteria for the future operation of the system. In 1953 the Commission created the International St. Lawrence River Board of Control to insure that the lake would be regulated according to those criteria. The regulation of Lake Ontario, then, is an international concern.

The construction of the Seaway consisted of two parts. First, extensive dredging was performed to provide enlarged channels for the deeper draft ocean vessels that would use the system and to allow for higher outflows through the river. The second part of the project was building control structures in the river which could be used to generate electrical power and to regulate the outflow from the lake.

Most of the time, the outflow from the lake is regulated solely at the Moses-Saunders Generating Station and Dam by allowing a specified amount of water to pass through its hydro-turbines. There are occasions, however, when some of the outflow is also discharged through the Long Sault Dam, which parallels the Moses-Saunders. This is used as a safety valve only in case of a mechanical breakdown at the Moses-Saunders or when the Board of Control directs an outflow too great to be passed by that dam alone. Until recently, use of the Long Sault Dam was very rare, but during the high lake level periods of 1973, 1974, and 1976, the equivalent of more than two feet of lake storage was discharged through that safety valve.

It should be pointed out that no electrical power can be generated at the Long Sault structure, and water passed through it is wasted as far as energy production is concerned.

Located nearby are the Eisenhower and Snell Locks—U.S. locks operated by the St. Lawrence Seaway Development Corporation. These structures are necessary to transport ships past the two dams and the 80-foot difference in river elevation they cause. A very small amount of water is passed through the locks (less than one-half percent of the total river flow).

The Moses-Saunders and Long Sault Dams and the locks effectively block off the St. Lawrence River and make some Lake Ontario regulation possible through control of its outflows.

System Hydraulics

The levels of the lake fluctuate in response to the difference between the total inflow to the lake and the total outflow from the lake. The equation is quite simple: Inflow − Outflow = Change in Storage (or, more clearly, the change in level). When the inflow is greater than the outflow, the lake goes up. When the inflow is less than outflow, it goes down.

The total inflow to Lake Ontario is a composite of several factors: inflow from the upper lakes, runoff and groundwater flow from the lake's own basin, and precipitation on the lake's surface. Total outflow from Lake Ontario essentially consists of the St. Lawrence River flow and evaporation from the lake surface. The latter is substantial, since in a normal year it averages about 24 inches.

Prior to regulation, the outflow from the lake was strictly a function of the lake level and the channel dimensions of the St. Lawrence River. During the spring, as temperatures rise, the previous winter's snowpack on Lake Ontario's basin begins to melt and swollen tributary streams carry the extra water into the lake. This, combined with the minimal evaporation at this time of year, results in an inflow greater than outflow and the lake level rises. This condition continues into June in most years, or until the increasing outflows catch up with the slowly decreasing inflows, at which time the lake level peaks.

In the succeeding months of summer and fall, evaporation becomes a significant factor and inflow from the streams continues to drop off. Thus, with outflows

View of Moses-Saunders Hydroelectric Generating Station. During normal supply conditions, over 99% of the lake outflow is controlled by regulating the flow through its turbines.

Lakeshore cottage being attacked by storm waves during the high levels of the 70s. Unwise lakefront development contributes to this problem.

greater than inflows, the lake levels fall. Winter precipitation is generally in the form of snow, which is stored on the land. The level drop continues through the winter months of December and January, and then the cycle begins again. The cyclic annual rise and fall is known as the seasonal fluctuation. Lake Ontario normally peaks in June, at a monthly average of 245.6 feet above sea level. It recedes to an annual low, usually in December, of about 244.0 feet above sea level, making the normal cycle about 1.6 feet.

During prolonged wet or dry periods on the Great Lakes Basin, all of the lakes tend to deviate from their normal levels and move up or down. The highest monthly mean level Lake Ontario has reached since 1860—when levels were first recorded—occurred in June 1952 when it peaked at 248.06 feet. The lowest was in November 1934, when it was down to a level of 241.45 feet. Both of those records were set before man began his efforts to regulate the lake.

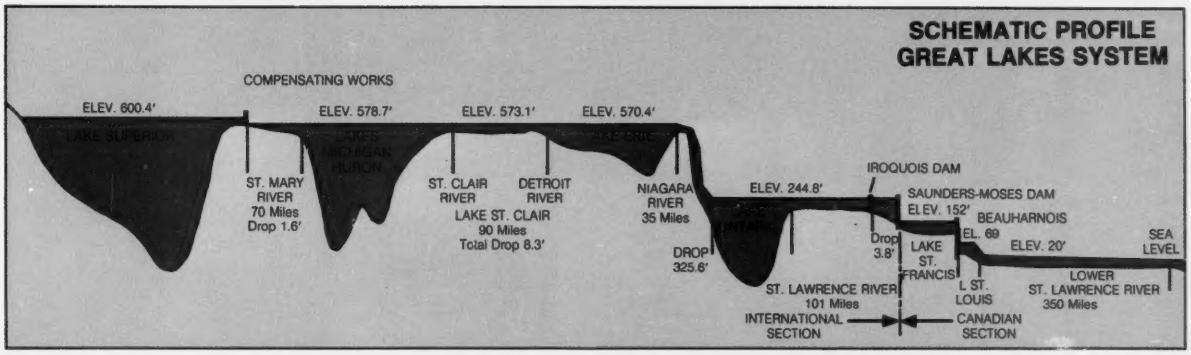
Objectives of Regulation

When the governments of the U.S. and Canada agreed to construct the St. Lawrence Seaway and Power Development Project, it was decided that its design would accomplish three objectives: provide a navigation system for deep draft ocean vessels to reach the Great Lakes; provide a means of producing low cost hydroelectric power; and provide benefits to shoreline property owners on Lake Ontario by reducing the severity of extremely high or low lake levels.

These objectives, however, may not always be achieved in consonance. The achievement of one objective to its maximum may tend to minimize the achievement of one or both of the others. To insure an equitable distribution of the benefits of regulation to riparian, navigation and power interests, then, the IJC established eleven criteria that subsequent regulation plans would have to meet.

It is not necessary to elaborate each of those criteria, but it may be of help to summarize how they generally relate to the various interests.

Regarding riparian interests, the IJC required that the lake be maintained "as nearly as may be," and the



Profile of the Great Lakes—St. Lawrence River System. Ontario is unique because it is the only Great Lake receiving flow from all the others. Yet, its surface area is only 24% of Superior's; 17% of Michigan-Huron's and 77% of Erie's.

occurrence of monthly mean levels about 245.8 feet be less frequent than would happen under preproject conditions. To safeguard the rights of downstream riparian interests, the Lake Ontario outflow during the annual flood discharge of Canada's Ottawa River (a major tributary to the St. Lawrence) and during serious ice conditions in Montreal Harbor, was to be no greater than would have occurred if the St. Lawrence Project had never been built. Flooding in the lower reaches of the Ottawa River near Montreal is very common during the annual spring runoff, so it is important that discharges from the St. Lawrence River not magnify the problems of flooding there. Therefore, the Commission established a criterion that Lake Ontario outflows during this period should be no greater than would have occurred naturally. There was no requirement, then, to improve conditions downstream.

The criteria also provide consideration for the power entities. The Commission specified that the regulation plan should provide the largest minimum outflow possible, compatible with the other criteria. For example, when the lake level is low and the Lake Ontario Basin is in a drought condition, outflows are reduced to prevent the lake level from falling even lower. The flow is required to remain above some minimum value, however, to continue to generate hydroelectric power on the St. Lawrence River.

The IJC also insisted that the regulation plan permit temporary decreases in outflows during the winter months to facilitate the formulation of a stable ice cover on the St. Lawrence River. This would minimize ice jamming and its consequent adverse effects on power production. Once the ice cover is properly formed and stabilized, the outflows usually are gradually increased for the remainder of the winter.

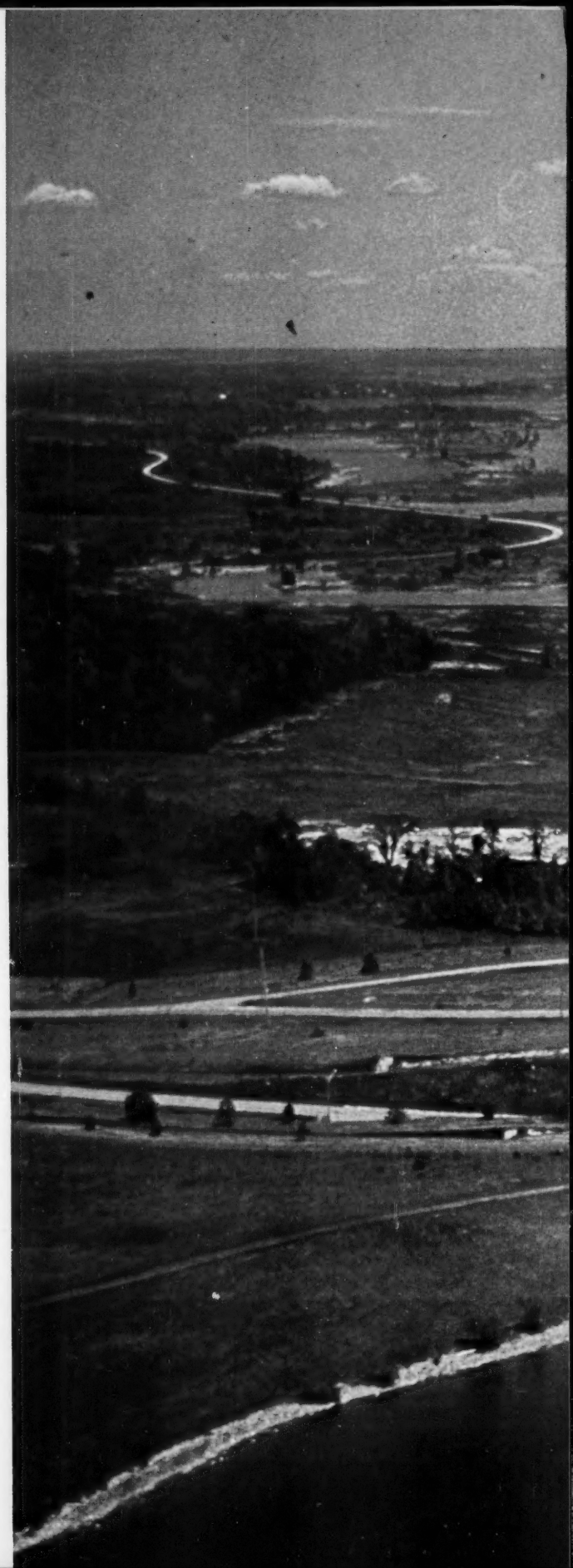
Finally, the criteria insure benefits for commercial shipping. They specified that the minimum elevation of Lake Ontario during the navigation season be at least 242.8 feet (low water datum). They also required that in times of drought and consequent reduced outflows from the Moses-Saunders Dam, downstream navigation interests should receive enough water to provide at least the river levels that nature would have given them. Additionally, limits were placed on the maximum permissible flow in the St. Lawrence River so that navigation channel velocities would not exceed four feet per second and that river levels in the reach from Lake Ontario to the new facilities opposite the Moses-Saunders Dam would not be reduced below the 27-foot minimum depth required for ocean-draft navigation.

Can It Be Done?

A regulation plan is simply a preconceived rule or set of rules to prescribe the outflow to be released (from the aforementioned dams) under various conditions of lake levels and inflows. Three such plans have been used since the beginning of regulation through the St. Lawrence Project.

The current plan, known as 1958-D, has been in effect since October 1963. Although it is highly technical in nature, it is quite simple in concept. On Thursday of each week the initial or tentative outflow for the coming week is calculated from the current lake level, the trend in water supply for the season, and the magnitude of recent supplies to Lake Ontario. This calculated or tentative outflow is then compared to several sets of maximum and minimum limiting criteria, such as those discussed earlier. If the tentative outflow is greater than the allowable maximum, only the maximum provided in the IJC's criteria may be discharged. Similarly, if the tentative outflow is less than the prescribed minimum, the pre-established minimum will take precedence. Only if the calculated outflow falls between the maximum and minimum limits is it selected and recommended for the coming week.

Of course, the IJC may direct departure from the plan during periods of extreme drought or high supply. The Commission has exercised this option four times since regulation began.



Commercial ship traffic through Eisenhower lock.
(St. Lawrence Seaway Development Corp. Photo.)

The current regulation plan was not easy to develop. It is the result of designing and testing literally hundreds of variations. Each was mathematically tested month by month over the entire period for which records of Lake Ontario were available—a period stretching from 1860 through 1954. The effectiveness of each proposed plan was judged by how well its resulting levels and flows during the 95-year test period would have satisfied the Commission's criteria.

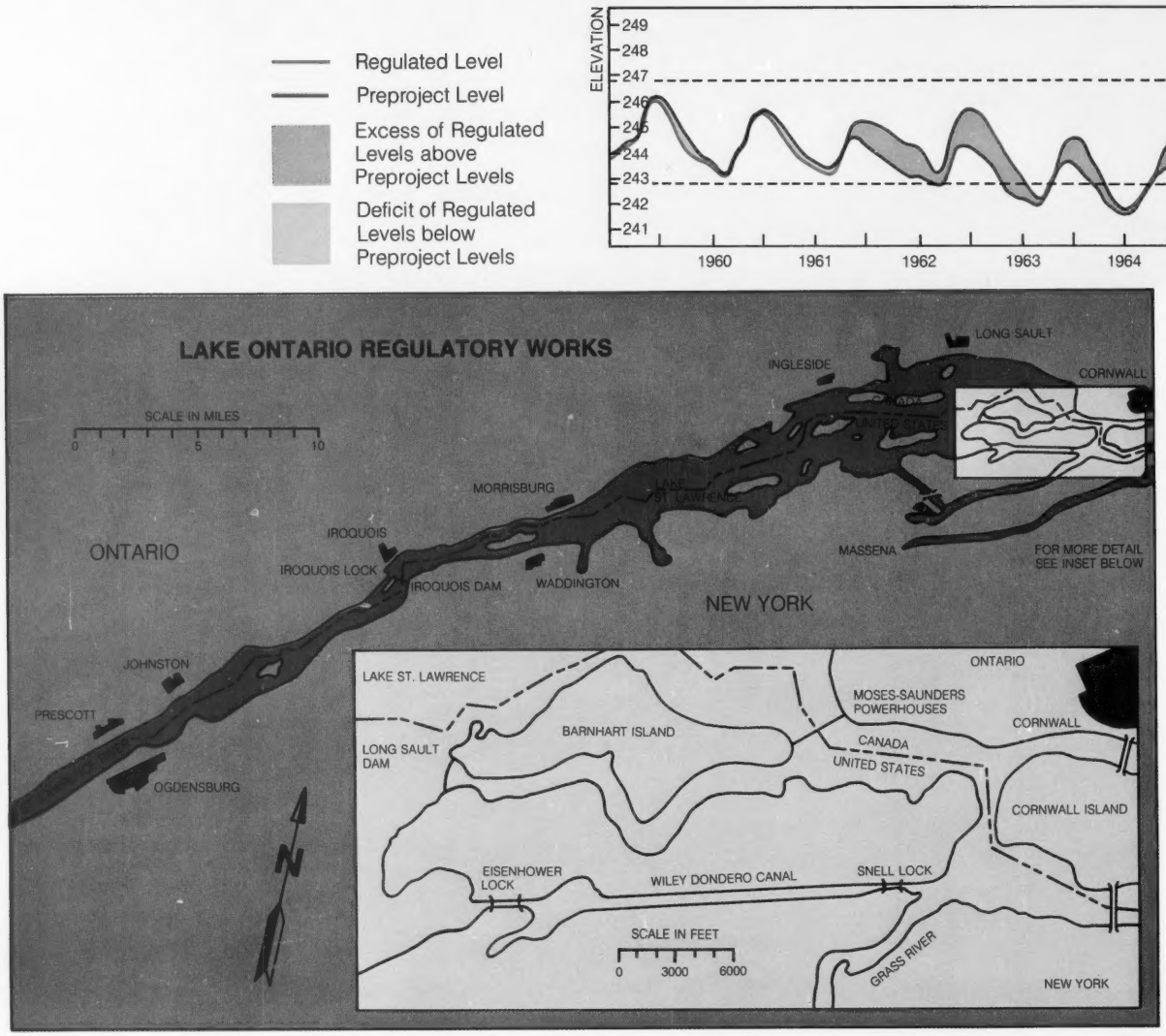
Other plans have been considered and mathematically tested since 1963, but none to date have appeared as satisfactory as Plan 1958-D.

Has Regulation Been Successful?

Obviously, no single plan can provide maximum benefits to riparian, shipping, and power interests at the same time. As stated before, an increase in benefits to one interest frequently means costs or losses to another. It seems unlikely, then, that any regulation plan will ever be considered a popular solution. It is this author's opinion, however, that the most equitable distribution of benefits to all concerned may be achieved when the lake levels most closely approximate their long-term norm. This would also have the least adverse environmental impact on the lake. In other words, a plan which tends to reduce the occurrence of either extremely high or low levels and tries to maintain levels of long term seasonal averages might be considered successful. By that standard, Plan 1958-D has done well.

Beginning in 1961, the Great Lakes Basin experienced four consecutive years of below normal precipitation. This produced supplies to Lake Ontario that were considerably lower than any which had been previously recorded. In that period, the Commission felt that it was necessary to deviate from Plan 1958-D.

Conversely, in late 1972, as a result of sustained excessive precipitation on the system, Lake Ontario began receiving supplies greater than any experienced in the recorded history of the lake. Again the plan had to be temporarily set aside.

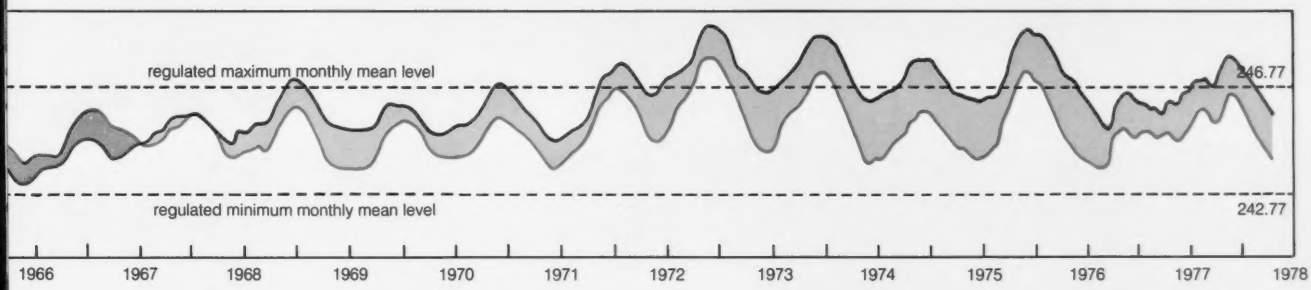


Detail of the control structures necessary for Lake Ontario regulation.

During these two recent periods of unusually low and high inflows, the Commission's recommended upper and lower limits for the lake level were exceeded. Specifically, the actual regulation procedure failed to maintain levels within the recommended range in 1964, 1973, 1974 and 1976. This would seem, then, to indicate that the plan has not worked effectively.

The actual situation, however, is quite the contrary. Although the plan, when subjected to record periods of drought or of high supplies, failed to maintain the recommended range, the levels which resulted for both periods were far more moderate than would have occurred without regulation.

It is relatively easy, of course, to determine what the levels would have been had the project never been built. Since the inflows to the lake have been recorded, and since the natural outflow capacity of the St. Lawrence River at given lake levels is known from preproject records, it is possible to calculate with considerable confidence what the actual lake levels would have been if Lake Ontario had been left to nature.

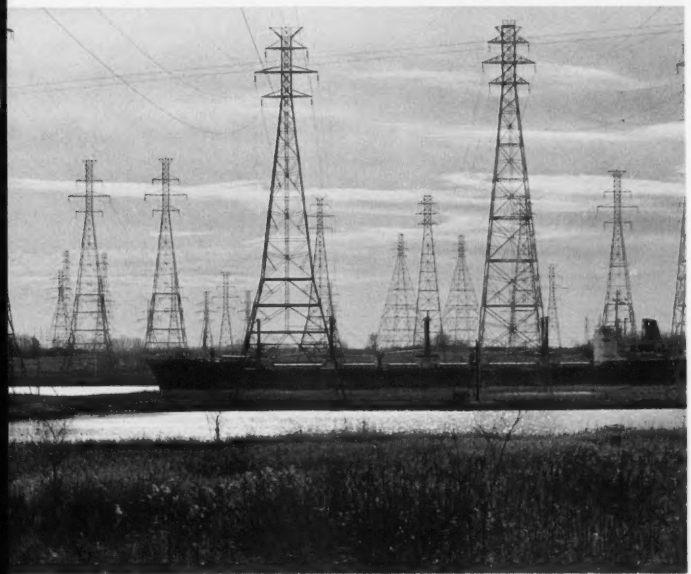


Graph of Lake Ontario Levels (1960-1978) comparing actual levels (regulated) with levels that would have occurred without regulation (preproject). Without regulation, Lake Ontario would have been above the recommended maximum (246.8 feet) for 51 months compared with the 11 which actually occurred. Similarly, without the project, (considering only navigation months) the lake would have been below the recommended minimum (242.8 feet) for five months compared with the one which actually occurred.

When such calculations are performed, the success of Plan 1958-D is impressive. During the drought conditions of the mid-1960s the level of the lake was kept a foot higher than it would have been under natural regulation. On the other extreme, the unusually high levels experienced since 1973 have been held to a minimum, with the actual lake level ranging from 13 to 28 inches below the disastrous levels that would have existed without the project.

The present plan has distributed the benefits and costs of the regulation project remarkably well among the various interests.

The riparian interests on the lake have benefited substantially during both drought and high water, although during the high level periods since 1973, these benefits, for many, have been in the form of reductions in damages rather than complete protection.

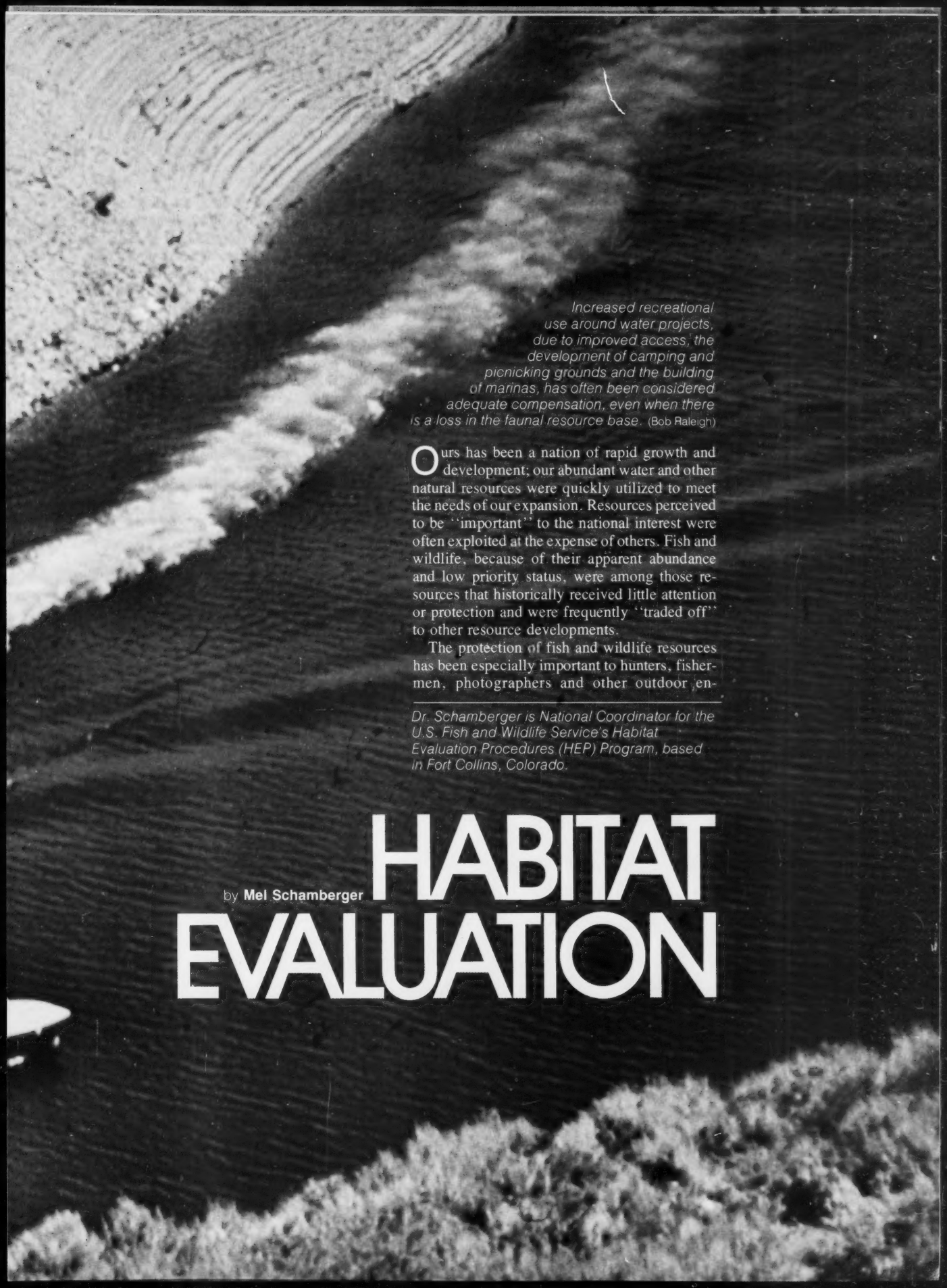


Commercial vessel moving under power lines carrying electricity generated at the Moses hydro station. The Moses (U.S.) and Saunders (Canada) portions of the power dam have a total installed capacity of 1.8 million kilowatts.

Shipping, on the other hand, has benefited during the periods of high supply, since greater harbor depths on the Great Lakes have permitted heavier loadings. But, on the St. Lawrence River, during 1973, 1974 and again in 1976, commercial traffic was often subjected to hazardous navigation conditions due to the high outflows from Lake Ontario. The maximum channel velocity criterion was liberally violated during those recent years.

Hydropower interests, too, have sustained both benefits and costs through regulation. Although the high supply period of the 1970s has provided tremendous amounts of water for power production, the high outflows required on several occasions since 1973 have been greater than the Moses-Saunders station can process. Thus, since 1973, the power entities have spilled a volume of water through the Long Sault Dam equivalent to 26 inches of storage on Lake Ontario. It was also necessary to waste this water a second time at the Beauharnois-Cedars hydropower complex downstream near Montreal.

It is apparent, then, that Plan 1958-D has contributed significant improvements to the conditions of Lake Ontario for a variety of interests. The regulation of Lake Ontario has reduced the detrimental impact of sustained periods of both high and low precipitation over the Great Lakes Basin for nearly two decades. The regulation plan was never designed to, nor has it ever been able to completely control, the natural phenomenon of Lake Ontario's rise and fall. Nature's ever changing supplies of water preclude this. ■



Increased recreational use around water projects, due to improved access, the development of camping and picnicking grounds and the building of marinas, has often been considered adequate compensation, even when there is a loss in the faunal resource base. (Bob Raleigh)

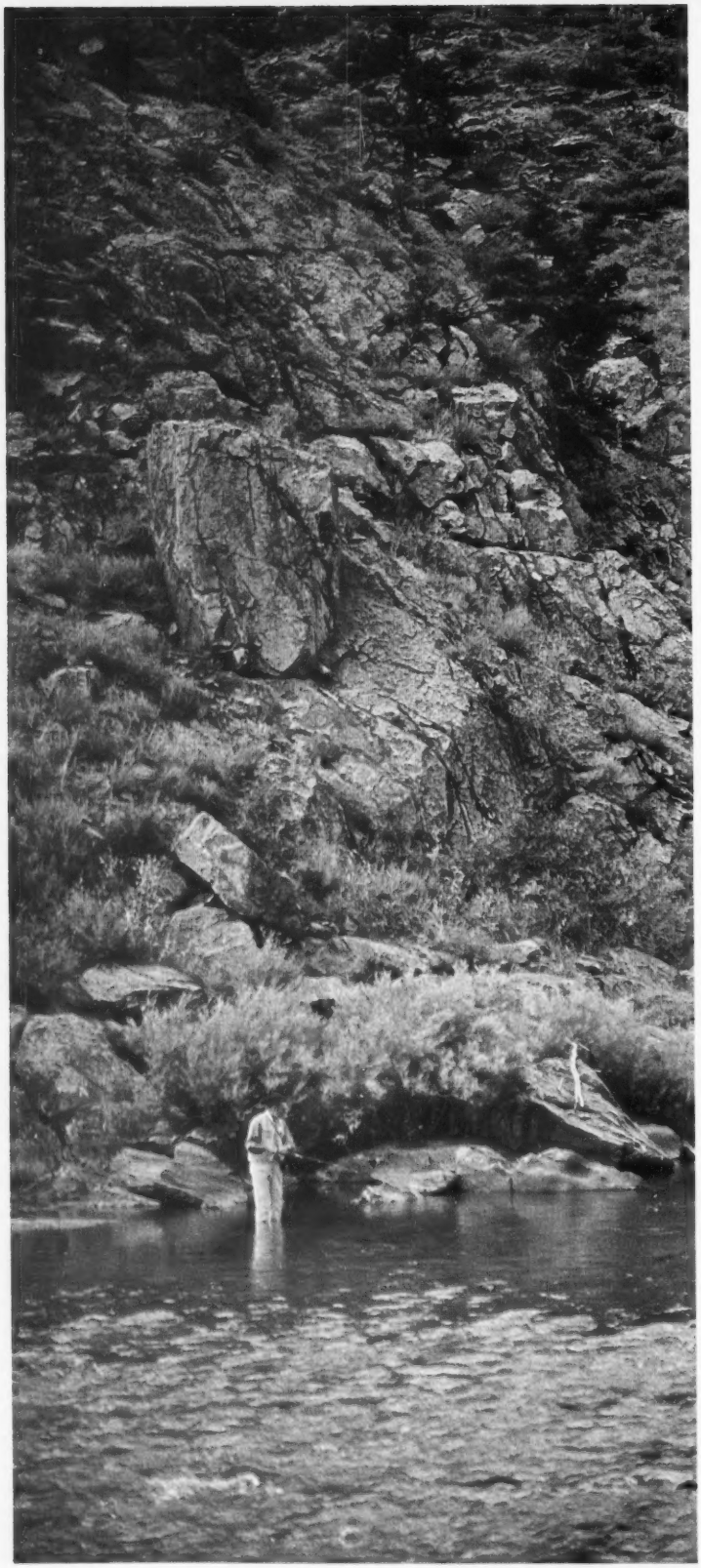
HABITAT EVALUATION

by **Mel Schamberger**

Ours has been a nation of rapid growth and development; our abundant water and other natural resources were quickly utilized to meet the needs of our expansion. Resources perceived to be "important" to the national interest were often exploited at the expense of others. Fish and wildlife, because of their apparent abundance and low priority status, were among those resources that historically received little attention or protection and were frequently "traded off" to other resource developments.

The protection of fish and wildlife resources has been especially important to hunters, fishermen, photographers and other outdoor en-

Dr. Schamberger is National Coordinator for the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP) Program, based in Fort Collins, Colorado.



Water projects may open up new opportunities for fishermen. The man-use day concept of mitigation counts these fishermen as enhancement even when they only redistribute their activity from one area to another. (Mel Schamberger)

thusiasts. These groups in the past were unable to find organized support for their concern that habitat needed to produce fish and wildlife was rapidly being converted to other resource development purposes. The traditional cost/benefit analyses of resource development projects has generally neglected fish and wildlife resources, partially because of the difficulty in determining their economic "value."

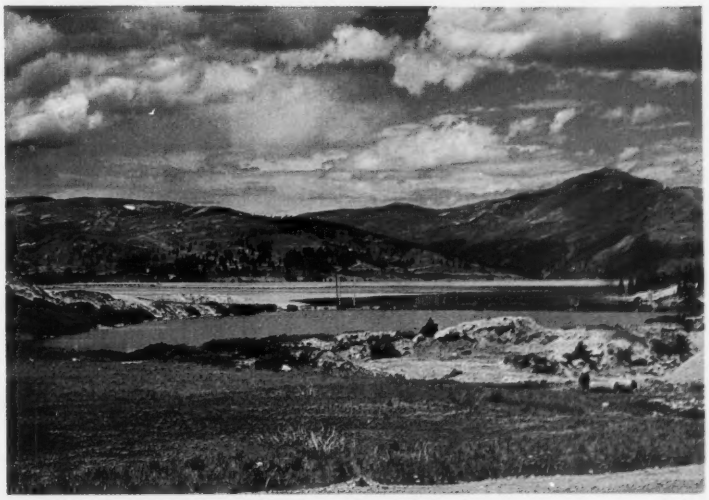
Our growing appreciation of environmental relationships and values in recent years has resulted in a greater concern for both water and fish and wildlife resources. The increasing scarcity of these two important resources is partially responsible for present conflicts between resource development and habitat protection.

A new era is now upon us: an era where environmental values *are* important and the concept of "development at all costs" is being replaced with "development—at what cost?" The American public is becoming increasingly aware of the benefits, both tangible and intangible, associated with protecting natural areas. There is great concern and even alarm at environmental losses and a reluctance to give up these resources needlessly. More leisure time, increased expendable income, greater mobility, and an appreciation of the enjoyment derived from fish and wildlife have contributed to increased consumptive and non-consumptive uses of these resources. We also have come to realize that once productive fish and wildlife habitat is lost, it is difficult, if not impossible, to replace.

The increased public concern for fish and wildlife resources has expressed itself through the enactment of legislation that clearly states that environmental values can no longer be ignored. "Business as usual" in the development of one resource at the total expense of others is no longer permitted. The National Environmental Policy Act, the Endangered Species Act, the Coastal Zone Management Act, the 404 Permit Program under the Federal Water Pollution Control Act, and the Wild and Scenic Rivers Act, to mention but a few laws, have translated public concern into legislative action.

The Principles and Standards for Planning Water and Related Land Resource Development, developed by the Water Resources Council, state that Environmental Quality (EQ) and National Economic Development (NED) are *equally* important and required planning objectives. In some cases Federal resource development planners have continued to optimize NED benefits while putting little emphasis on EQ ob-

The potential impact of alternate project sites and plans on fish and wildlife resources can be evaluated and displayed early in the project planning through the use of HEP. (Cathy Short)



jectives. Environmental Quality is seldom given the "equal consideration" required under the Principles and Standards (P&S).

President Carter's Water Resource Policy Message (June 1978) has further emphasized that "Sensitivity to environmental protection must be an important aspect of all water-related planning management decisions." This Message contained a directive to the Secretary of the Interior and other Federal agency heads to "im-

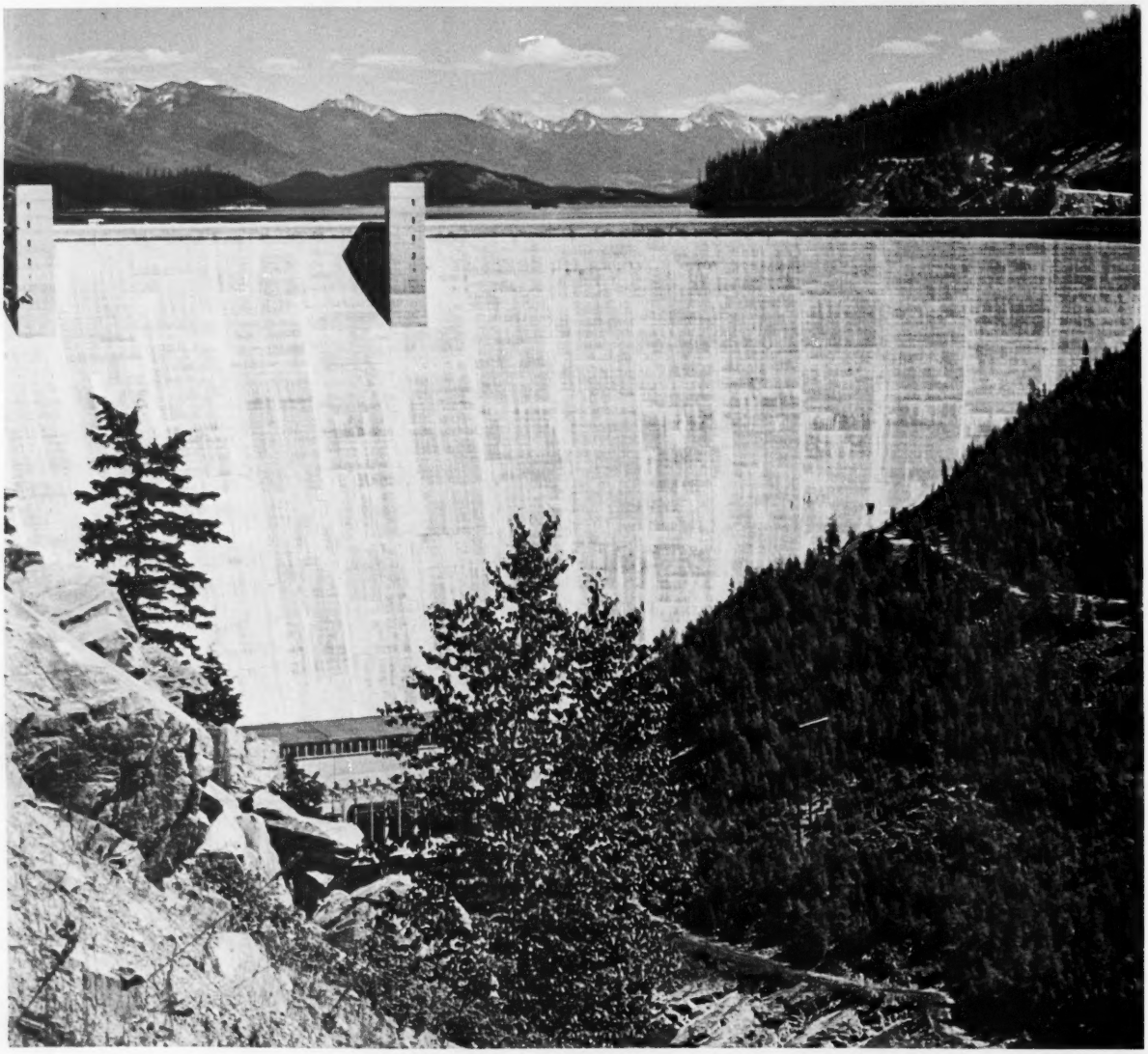
Public opinion, legislative actions, and Presidential mandates have recently expressed a strong concern over how best to protect our fish and wildlife resources. (Rich Schroeder)

plement rigorously the Fish and Wildlife Coordination Act, the Historic Preservation Act and other environmental statutes'' so that water projects are developed that are cost effective, safe and environmentally sound.

It is clear that public concern, legislative mandates, and Presidential directives demand that resource developers plan their projects with consideration for environmental concerns and that environmental losses related to Federal projects must be mitigated. The real question is no longer ''if'' but ''how'' this protection of fish and wildlife resources can best be accomplished.

Steep-wall canyons provide excellent dam sites and illustrate the current conflict between the development of our water resources and the protection of fish and wildlife habitat. (Photo by Cathy Short)

One of the greatest problems associated with the protection of fish and wildlife resources has been the difficulty of quantifying their value. The traditional methodology was based on the ''man-day of use'' concept. Fish and wildlife concerns were considered to be mitigated if an area supported the same number of days of fishing and hunting after completion of the project as it did before. This approach to mitigation considers neither the quality of the resource nor the amount of resource available and can result in a distorted picture of the actual impact to fish and wildlife that results from project implementation. Consider, for example, an area with a resource base that could supply a *potential* of 10,000 man-days of use before a project and 6000 man-days of use after its construction. The impact of this project would be considered mitigated if the area supported a *demand* of 3000



man-days of use both before and after project development, even though a tremendous loss occurred to the resource base (4000 potential man-days of use). This loss in productivity would not be mitigated because the *demand* never exceeded the *potential* supply, and no reduction in actual man-days of use occurred.

Another problem inherent in the man-day use approach to project evaluation is its inability to account for displaced use. Enhancement benefits may be claimed by a resource development agency with this method simply on the basis of redistribution of either the resource or an already existing use of the resource. An example of claiming the redistribution of an existing resource as enhancement concerns the changing pattern of waterfowl hunting in response to reservoir construction. Reservoirs built along migratory flyways often attract and concentrate large numbers of ducks and geese. This results in an increase in waterfowl hunting in the project area and is considered a project benefit. The reservoir itself, however, may not produce additional waterfowl; it may only redistribute an already existing resource. In this case, the gains displayed for the project area may be at the expense of other areas; waterfowl once available for harvest in Arizona are now "shortstopped" and harvested in Colorado. Should this population redistribution realistically be counted as enhancement by a resource development agency? A more legitimate case for enhancement would be a reservoir that actually results in an increased annual production of, for example, 1000 ducks. The additional waterfowl production may add 500 new days of hunting. These kinds of actual increases in the resource base can and should be considered project benefits.

A second and related redistribution problem involves the users themselves. The first impoundments in Kansas, for example, increased the area available for warm water fishing, and large numbers of fishermen made use of the new opportunity. As additional reservoirs were later built within a few miles of the first one, the fishermen may redistribute their activity with few or no new fishermen attracted to the area. Water resource development agencies count as enhancement the fishing days attributable to each new reservoir even though no *new* fishing days occur. The same fishermen continue to be counted in the benefit/cost ratio for each new reservoir that is built even though use of nearby reservoirs may be reduced. These, and other problems, make it obvious that project evaluations based on man-days of use do not adequately consider the resource base and its potential productivity.

The U.S. Fish and Wildlife Service (USFWS) has developed a methodology designed to overcome the problems associated with the man-day of use approach to project planning by focusing, instead, on the habitat and its associated productivity. This system, the Habitat Evaluation Procedures (HEP), provides a standardized means of quantifying fish and wildlife values. The HEP can be used at all stages of resource project planning. They provide a standardized data base to assess impacts on fish and wildlife for the evaluation of alternate project sites and plans and to determine what measures, if any, are needed for mitigation and/or compensation. The greatest value of the HEP is their application and usefulness throughout the planning process.

The HEP methodology was designed to provide an objective and quantitative estimate of the "value" of fish and wildlife resources. Habitat quality and quantity are integrated in a single index value called Habitat Units, based on measurable criteria in the habitat known to be important in providing the life requisites of the fish and wildlife species of interest. Measurements for a specific sample site or area are compared against ideal conditions for species found in the habitat being evaluated. The Procedures provide both a description of baseline conditions and a comparative display of any number of potential future conditions. Future-

New reservoirs along flyways tend to attract and concentrate migratory waterfowl, and birds once harvested in Arizona may now be harvested in Colorado. This redistribution of an existing resource is often counted as a project benefit, even though there is no increase in the resource base. (Cathy Short)

with-project conditions can be compared with each other and against baseline conditions or future-without-project conditions for the target years desired. The difference between with-project and without-project index values demonstrates the magnitude of the impact. The HEP provide the type of display useful to planners and decisionmakers when evaluating environmental/economic tradeoffs.

The HEP have been under development and refinement for the past five years. They were published in 1974 as the Ecological Planning and Evaluation Procedures for field use by the USFWS; this document was shortened, revised, and published as the Habitat Evaluation Procedures in 1976. A new draft of the Procedures is currently being reviewed and publication is anticipated by mid-1979. This latest revision addresses a number of the problems associated with earlier applications of the Procedures. The HEP will accommodate evaluations of individual species throughout the evaluation process, as well as evaluations of habitat types. Improved guidance for the selection of species and habitat types used in the evaluations will be included in the revised HEP. Although the Procedures have been associated primarily with the mitigation process in the past, the new manual will stress their utility throughout the planning process. There will be less need to focus on mitigation if early planning includes environmental quality as well as economic development objectives. The revised HEP also will provide guidelines to determine relative values of unlike habitats for use in planning and mitigation determinations. Improved software routines are being developed to facilitate data display.

One significant improvement in the Procedures is the development of criteria that will increase reliability and replicability of field evaluations. These criteria will be in the form of species-oriented data bases and are now being developed on a regional basis for publication as aquatic and terrestrial "Habitat Evaluation Criteria Handbooks". A number of terrestrial Handbooks are currently available in draft form. The Service plans to produce approximately 50 terrestrial, 25 freshwater, and 25 coastal salt water Handbooks over the next several years.

The conceptual premises on which the Procedures are based are undergoing testing through several research programs. The Soil Conservation Service, Army Corps of Engineers, and Bureau of Reclamation have provided staff to assist the Project Impact Evaluation Team in the refinement of the HEP and to express their own agency perspectives towards habitat evaluation. The Service established the Project Impact Evaluation Team in Fort Collins, Colorado in 1977 to oversee further development, refinement, and implementation of the HEP.

The HEP are used by the Division of Ecological Services, USFWS, when evaluating water resource development projects where Federal funds are involved. They are being used extensively throughout the United States on more than 125 Army Corps of Engineers, Bureau of Reclamation, and Soil Conservation Service projects. Since the time required for the entire planning process is lengthy, only a handful of these projects have reached the point where the HEP analysis has been completed and reports submitted. Several of the projects that have incorporated the HEP in their planning process have resulted in agreement among the project spon-

The careful blending of resource development and environmental protection can result in projects that answer our nation's water needs without needlessly sacrificing fish and wildlife habitat. (Dave Chalk)

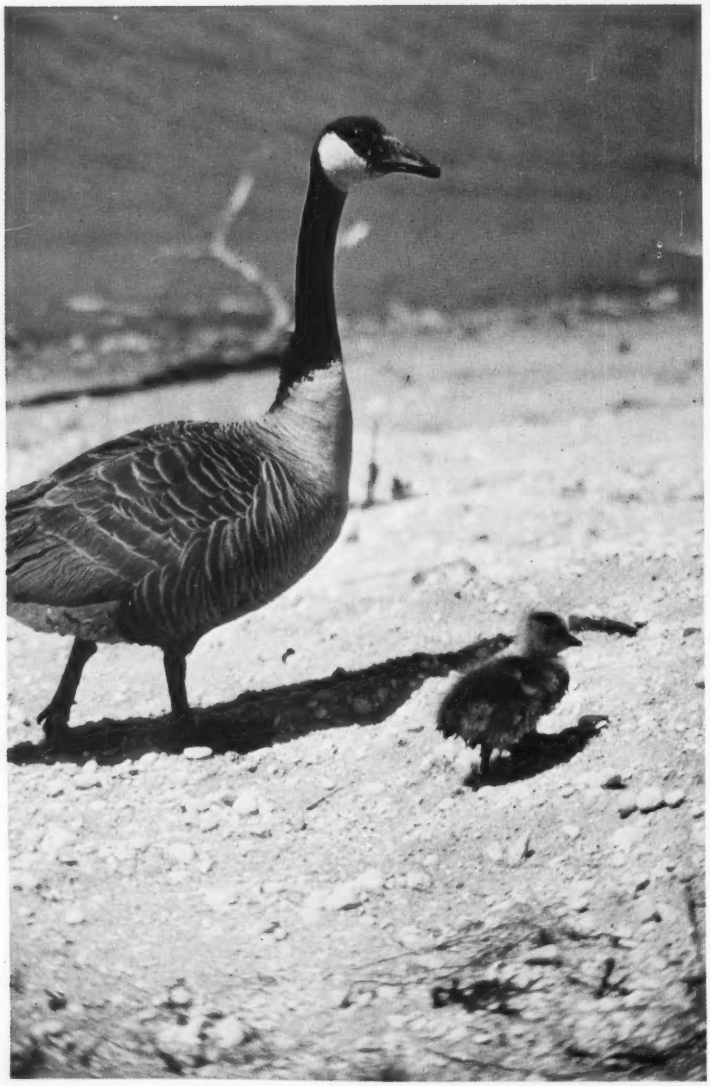
Deer already present on land purchased for compensation do not replace deer lost because of project impacts. Productivity must be increased through management, to offset resource base losses that occur within the project area. (Cathy Short)

sors, lead planning agency, state agencies, and the Service in planning for fish and wildlife objectives.

The concept of mitigation is not new. Unfortunately, application of this concept has been very lethargic and the lack of a standardized, quantitative methodology for measuring habitat losses has further complicated this aspect of project planning. The HEP fill this gap by providing estimates of the number of acres, under different levels of management, that will be necessary to offset the fish and wildlife productivity lost through project implementation.

The Procedures take a habitat productivity approach when planning for mitigation and compensation and are based on the extent to which the resource is impacted rather than on changes in man's use of that resource. Credit is not given for simply purchasing replacement land unless management of that land prevents further loss of fish and wildlife resources. Existing wildlife values in replacement areas must be increased through management to compensate for productivity losses in the project area. The purchase of land containing 100 deer, for example, does not compensate for 100 deer lost through project development. The land must be managed to produce an additional 100 deer in order to compensate for the productivity lost in the project area. Various combinations of land acquisition and management options may be considered with the HEP to determine which possibilities will fulfill mitigation/compensation requirements. When several potential plans will accomplish fish and wildlife resource objectives, they can also be evaluated for financial or political desirability.

Habitat productivity is the best measure of its value. The HEP, by evaluating habitat on this basis, avoids many of the problems associated with man-use day approaches to project analysis. (Rick Schroeder)



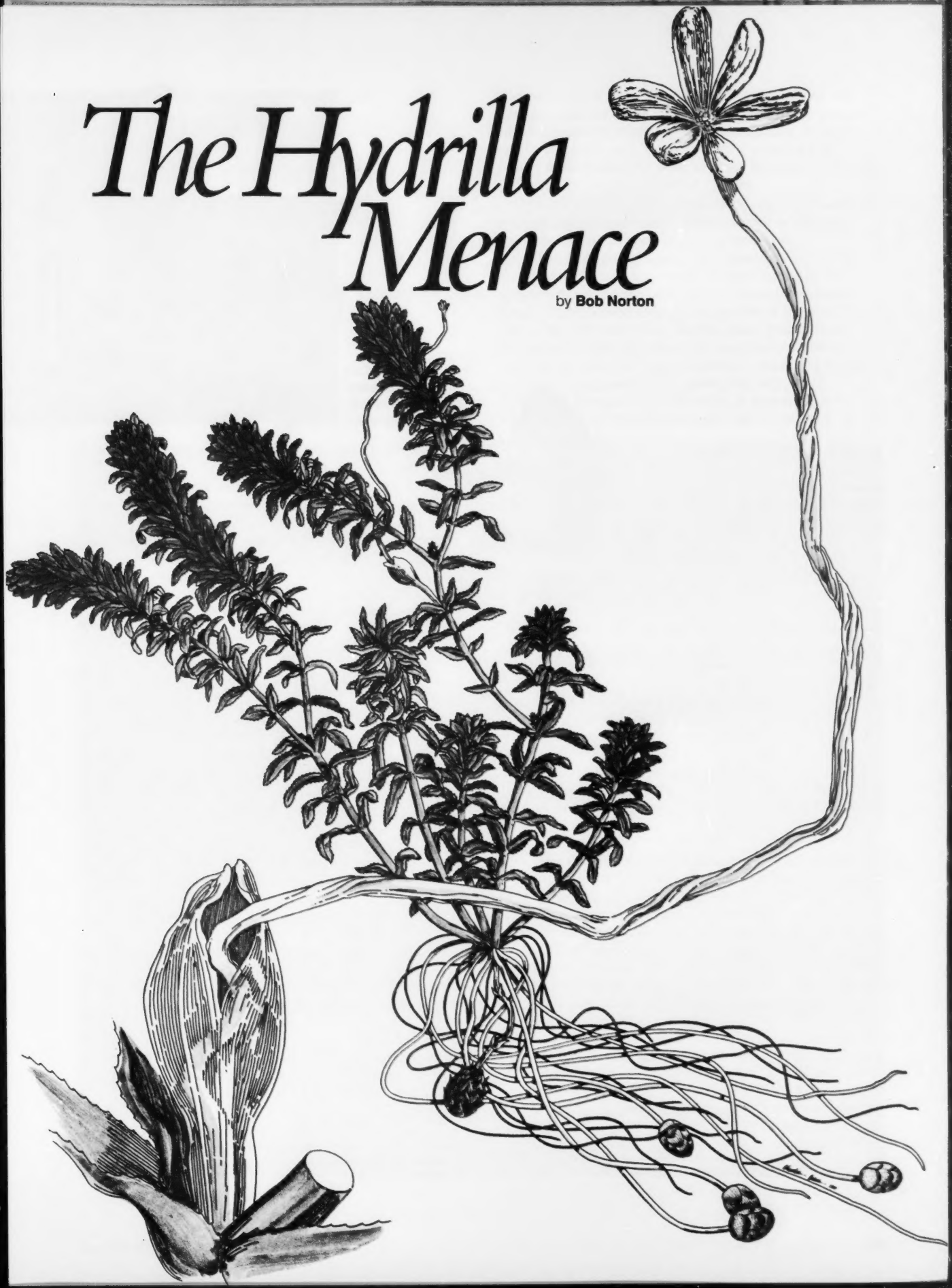
The use of habitat productivity rather than man-days of use has raised interesting conceptual questions. Consider the example where a project is being built and an acceptable mitigation plan has been agreed upon by project sponsors and state and Federal agencies. The selected mitigation plan provides for 80% mitigation of wildlife productivity, resulting in a 20% loss in the resident population of big-game species. The plan calls for improved access to the area, construction of a campground, and improved habitat quality on the mitigation land. Hunter use of the area is expected to increase to four times that which would occur without the project. The question becomes: "Can the development agency claim enhancement benefits on the basis of increased use when there has actually been a loss of 20% of the resource base?"

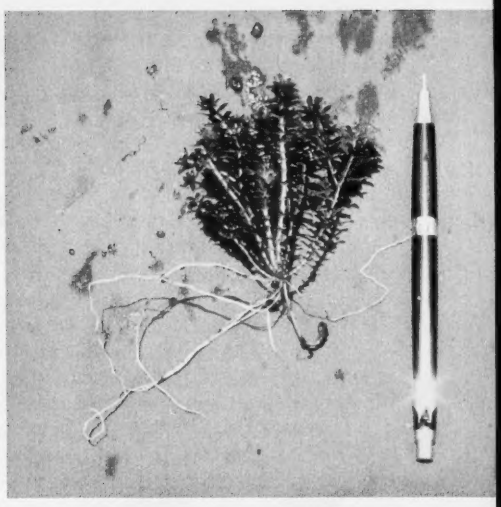
This question may at first appear insignificant. The designation of project features as mitigation, compensation, or enhancement, may determine which agency assumes the cost for that feature. There also may be conflicting regulations on the administration cost, when costs are shared by various Federal agencies. Disagreements over the definition of a feature, as either mitigation or enhancement, can result in the elimination of that feature from a project, allowing even further losses of fish and wildlife habitat.

The time has come for a realistic approach to the allocation of our natural resources. This nation has expressed its concern for protecting its environmental quality. Resource development must occur without the wholesale destruction of fish and wildlife habitat. Man's use of the resource has proved to be an unsatisfactory method of measuring habitat value. The Service has developed the Habitat Evaluation Procedures to fill this need by quantitatively measuring the value of habitat to fish and wildlife. These Procedures are a standardized, quantitative methodology designed for use in resource development planning. They provide, for the first time, a method of displaying environmental values in such a manner that environmental quality can now be included as a bona fide objective in resource planning. Resource planning agencies cannot continue to ignore environmental values. They must consider, in a meaningful manner, environmental quality objectives in the planning process. ■

The Hydrilla Menace

by **Bob Norton**





A hydrilla verticillata *plant from Lake Ocklawaha, Florida.*
(CofE Photos)

In 1960, near Miami, Florida, a disenchanted tropical fish hobbyist emptied his small aquarium into the canal behind his home. The guppies and angelfish were immediately dined on by a cruising school of largemouth bass. The sand and multi-colored pebbles settled to the bottom of the channel. The algae bloom dispersed and died. Only the *hydrilla verticillata*—three sprigs totaling about 12 inches—survived this living room-to-lagoon disruption. Within a week they had rooted themselves deep into the hospitable muck on the canal bottom and spread downward and laterally. Now a compact mass of submergent aquatic weed, the hydrilla enjoyed a geometric reproduction capability, lacked a predator species, and were ready to thrive in any temperature zone from the arctic to the tropics. The stage was set.

Aquatic biologists agree on the probability of the scenario above; the inadvertent, mindless introduction of the exotic hydrilla species into an American waterway. Nearly 20 years later, they do not agree on the remedy—or even if there is one.

Hydrilla is now known—less than two decades later—to have invaded and infested nearly 700,000 aquatic acres in the United States. It blankets Florida. Lake Orange is covered with a mat of hydrilla that even powerful motorboats cannot penetrate. Lakes Conway, Okeechobee, Jackson, the Polk County Chain o' Lakes and the St. John's River are among its hosts. The canals in the flood district of south Florida are bank full of the noxious weed.

It is in neighboring Georgia, Alabama, Mississippi and Louisiana, and as far north as Iowa and as far west as California. In California, there are several thousand acres affected in the Imperial Irrigation District—where, in some cases, vital water flow is reduced by about 90 percent. Hydrilla infestation of the entire American southwest, through the lower Colorado River, is threatened by the California outbreak. The Tennessee Valley Authority lakes are dead center in its northward route of expansion.

Bob Norton is the editor of Water Spectrum.

Hydrilla, the fire ant and killer bee of the weed world, is on the march.

Texas has it, and has undergone a typical hydrilla quantum leap from 1200 acres in 1976 to nearly 9000 acres in 1978. Lake Conroe in the eastern part of the state is particularly afflicted. Other states have also reported its presence, and it undoubtedly is there and merely awaiting confirmation in yet undetermined locations. The problem is far, far worse than that presented by water hyacinth. The hyacinth can be controlled and managed—the chemical 2,4-D herbicide is among effective agents. Nothing, to date, stops hydrilla.

To demonstrate its spectacular growth rate is to look no farther than Georgia's Lake Seminole. In the fall of 1975 there were 600 hydrilla-infested acres on the lake. Almost a tourist attraction. Less than a year later, the weed covered 1500 acres and was propagating itself in every direction. A tourist turn-off! A single hydrilla parent plant can grow an inch a day, and it possesses an unusual, dual reproductive capability—both vegetative and seed.

Hydrilla's intra-waterway migration is aided and abetted by American recreation habits. Hydrilla readily adheres to a boat's propeller blades and taken home at vacation's end. When the boat is relaunched at its homeport—perhaps in a previously hydrilla-free lake, the weed has a new home. Trailers, fish livewells and automobile undercarriages also provide transport. Waterfowl may carry it from lake to lake in their gizzards.

Florida, belatedly, prohibited hydrilla importation by the aquarium industry. The "barn door" was not closed in time, and there is still no funded Federal regulation[1] to bar its importation through all ports of entry into the U.S.

Identification

During the early 1960s, in the initial phases of hydrilla's south-to-north and south-to-west migrations, it was mistakenly identified as a sub-species of *Elodea*

[1]*Even though the legislation, PL 93-629, is not fully funded, the USDA's Animal and Plant Health Inspection Service has the responsibility under its current appropriations to exercise control under Title 7, CFR 41-49987.*

Typical hydrilla *encroachment is shown on Lake Nelson, Florida.*

(Canadeusus); a water weed common to the central and northern portions of the U.S. and no threat to the aquatic environment. The mistake was understandable; it is very similar to Elodea and, being an exotic, would not be readily differentiated by even a trained biologist. Not until 1965 was it correctly identified.

Hydrilla is distinguished from Elodea by its serrated leaf margins and pointed spines. The underside of the leaf, along the midrib or spine, is also spined. It is long-stemmed and branched, with oppositely arranged leaves at the bottom and whorls of three leaves on the upper portions of the plant. The leaves are oval-shaped. Small, white flowers float on the surface of the hydrilla mat in late summer or fall. Identification problems are compounded since leaves are not necessarily identical between sub-species. Leaf appearance, number of leaves per node, and general plant appearance may vary.

Hydrilla is negatively heliotropic; it normally grows downward away from the sun and expands laterally. It

Waterfront real estate values may plummet as a result of hydrilla infestations.

normally begins in the deepest reaches of the parent body of water and spreads into the shallows. By the time it finally appears near the surface, it has a major foothold in the waterway and has been laying tubers in the substrate for up to three years.

Initial effects are highly desirable. Vegetation suddenly appears in the deep zone, increasing game fish populations by providing cover and a habitat for prey species. The real problem starts following the lateral expansion—the unnoticed movement—when the hydrilla expands to the surface. Here, it forms its distinctive thick mats and blocks out sunlight to the beneficial plants below. Swimming becomes singularly dangerous; swimmers may entangle in the mat and drown. Outboard motors rapidly overheat, if, indeed, they can get underway at all. Prey fish hide in the plant and deny game species a food source. Mosquitos and other insect pests breed and thrive in the rotting surface vegetation. The weed fouls props, snags fishing lines, causes stunting of fish populations and blocks water intake pipes. Shellfish beds are smothered. Waterfront real estate values plummet.

Normal states of aquatic growth are healthful and necessary to a water ecosystem's equilibrium. The plants provide food, shelter and shade for animal organisms, provide oxygen through osmosis, and other nutrients such as nitrogen and phosphorous through death and decay, while assisting in the stabilization of bottom sediments. Hydrilla infestation is a growth state gone berserk. It spreads so voraciously and uncontrollably that it threatens to entirely choke out the waterway. Recreational and aesthetic values of the waterway are lost. Indeed, the hydrilla mat can become so thick, and so infused with dust, dirt and decayed animal and vegetable material, that its host is no longer a waterway. The rapid nutrient overloading hastens eutrophication and the waterway dies. It's just too much of a good thing.

Treatment Methods

Any treatment methodology must take into consideration the best compromise between the post-treatment *use* of the waterway—is full elimination or merely control of the hydrilla required?; the *safety* of the treatment method—both to humans and the surrounding environment, over long- and short-term calendars; the *effectiveness* of the treatment—the cost/benefit ratio; and, the long-term capital investment.

Submersed weeds, such as hydrilla, are perhaps the most serious of aquatic growths, since they cannot be sprayed readily with herbicides, and do not easily lend themselves to clearance by machines. Good intentioned control programs become, in reality, maintenance programs—wherein all effort is expended merely to keep the weed within liveable limits.

Many scientists, when faced with hydrilla, have totally discarded the word "eradication" in favor of "sustained management."

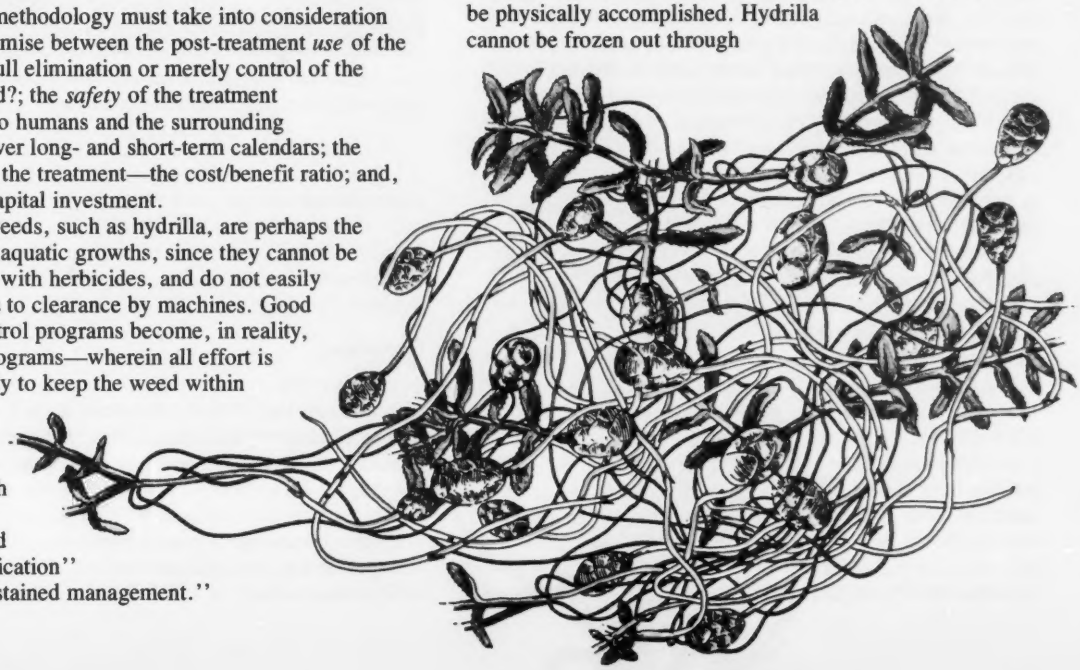
Mechanical

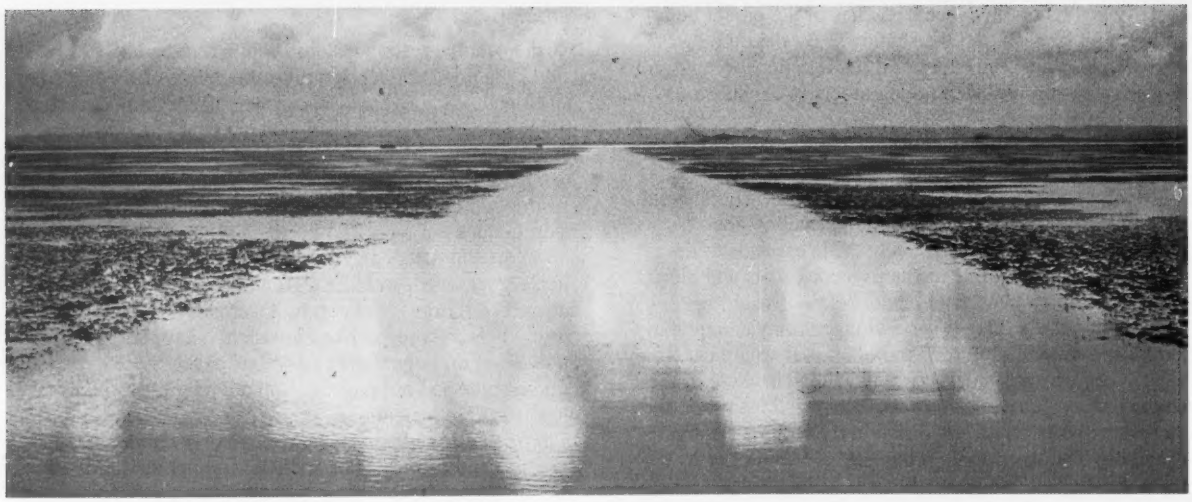
Mechanical harvesting became popular in the late 1930s and lasted about a decade until more potent chemicals were developed. Although still in use, and undergoing constant refinement, mechanical removal techniques are the most labor intensive, time consuming and least effective. They include pulling, raking, digging, draining and dredging.

Simply pulling up stems and surface enmattments of hydrilla does not work. It has no effect on the sub-hydrosoil tubers and root systems, and, as a submergent weed, hydrilla's growth is primarily subsurface. Large weed cutting machines—from portable cutting bars to combinelike harvesters—have some application on large bodies of water, but they are cumbersome and not mobile around docks and close-to-shore recreational areas. The capital expenditure is high (the best methods thus developed still approach $200 per acre) and can rarely be tried as an individual property owner effort. Further, these Rube Goldberg devices disrupt bottom sediments and create at least temporary turbidity. Cutting must not be done when desirable fish species are on the spawning beds. Cutting produces hydrilla fragments that may be scattered by current and wave action and invade areas where there was previously no infestation. The resulting fragments reproduce faster than the enmatted plants. Cutting indiscriminately reduces desirable plant species, and, as yet, the harvesters do not remove algae with any degree of efficiency.

Conversely, mechanical harvesters do not necessitate closing of the waterway—as may be the case with chemicals—and there is immediate benefit. With concurrent removal of the cut vegetation from the waterway, nutrient loading, sedimentation and navigational impedance are not factors.

Water drawdown has had some success, but there are two obvious disadvantages. Lowered, unnatural water levels can adversely affect beneficial species, and there are a limited number of bodies of water where drawdown can be physically accomplished. Hydrilla cannot be frozen out through





A trail cut through the hydrilla *by an Aqua-Trio on Orange Lake.*

planned drawdown to expose it to severe northern temperatures; the cold does not penetrate to the subsoil tubers.

Dredging is a most efficient mechanical method as it tends to destroy both existing plants and their root structures. Problems, however, include the complete disruption of the aquatic environment and the disposal of the dredged material.

Some experimenters have used plastic liners sunk to waterway bottoms and covered with gravel in an attempt to inhibit the hydrilla's growth—in effect creating a false bottom. Use is limited to small bodies with gently sloping, regular shorelines and some beach areas. Maintenance is a continuing problem. Shading of the hydrilla growth, prior to its surfacing, has been tried with varying successes. The shade element is normally an algal bloom, or selective dye, that prevents sunlight from penetrating to—and nourishing—the hydrilla's growth. Often, however, these blooms have over-developed and become a problem in themselves by increasing nutrient loading and subsequent additional plant growth. The planktonic blooms certainly do not add to recreational and aesthetic values, in any case, and certain species cause odor problems.

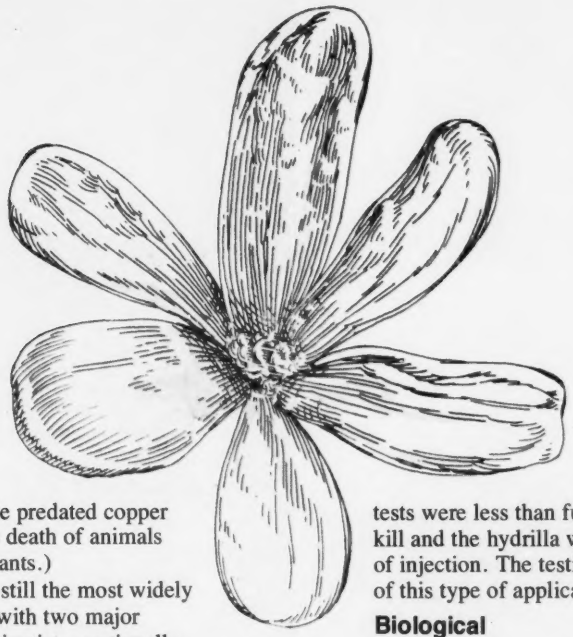
When the water is to be used for eventual human or animal consumption, there may be no other approach than mechanical removal . . . again and again. This also holds true if the waterway is adjacent to valuable cropland. But this begs the question. What do you do with the massive, foul-smelling piles of the cut weed when you get it on the bank? It won't burn. Explosives merely spread it. It is hardly an alternative energy source. Canada has had some limited success, on an experimental basis, in using harvested aquatic weed (not hydrilla) as the bulk ingredient in cattle feed. The cattle that dined on the weed did at least as well as the control group eating more conventional fare, but hydrilla's high water/fiber ratio limits its value.

The Aqua-Trio harvester & transporter have been used extensively in southeastern waterways.

Chemical

Applications of chemicals are a common and relatively effective *control* method. Chemicals do not eliminate the problem, however, because of their ineffectiveness in attacking the root systems. They provide a long-lasting control, are less labor-intensive, and are generally easy to apply.

Copper complexes are used primarily—in varying strengths and in combination with other materials such as triethanolamine and diquat. It was one of the earliest



herbicides (sodium arsenite predated copper (1902) but also caused the death of animals browsing on the treated plants.)

Copper compounds are still the most widely used chemical today, but with two major disadvantages that keep scientists continually looking for a replacement: Copper precipitate can build up in fish tissues, and occasionally cause the outright death of fingerlings of certain species. Secondly, the herbicide has a short contact (killing) time and leaves no active material to thwart the return of the plant growth—large quantities and frequent reapplications are needed.

Chemicals are most effective when the hydrilla is actively growing but has not yet gone to seed. They can be dispersed by hand, in granular form, in small bodies of water (less than one acre) and along the shorelines. Backpack and boat-mounted spray applicators—many on-board boat bailers are easily adaptive to this use—are required on larger bodies of water. Power operated equipment configured for chemical broadcast operation is essential for large treatment problems, and very large or inaccessible waterways will require airborne delivery techniques. Helicopters have been used successfully—for delivery, at least—in several locations.

After chemical application, hydrilla masses should show signs of weakness or death within two weeks. Discoloration or drooping are positive indicators that the chemical is at work. Tough stemmed and well rooted mats may remain standing until broken up by wind or waves, or boat propellers. Most noxious plants—terrestrial and aquatic—will eventually display resistance to chemical application and necessitate use of alternate compounds or increased dosages to maintain control. The chemicals currently in use eventually biodegrade and are absorbed into the environment with no lasting effects so far discovered.

In a multi-agency test in 1971, along Florida's Withlacoochee River, various strengths of diquat/copper sulfate were applied from airboats through drop-booms. The herbicide was injected 2-3 feet below the surface. The tests were less than fully successful; there was some fish kill and the hydrilla was largely unaffected below the level of injection. The testing did, however, show the feasibility of this type of application.

Biological

Most biological controls feature the introduction of an exotic species into the biota in an attempt to control the hydrilla spread—turning nature against herself. Although most authorities agree that the ultimate answer to the hydrilla menace will come from biology, it is also the area most fraught with danger. Introduction of a new specie, with unknown reproduction patterns, competitive demands on indigenous species, and other encroachment habits, can cause total and irreversible ecological disruption that far surpasses the original disturbance in scope. Indeed, all potential biological agents are required to go through the Department of Agriculture's quarantine process prior to release in this country. This is added insurance against damage to non-target species.

The White Amur *(Ctenopharyngodon idella),* or grass carp—and fish of the genus Tilapia—have been introduced into U.S. waterways as herbivoric biocontrols—simply stated, to eat the hydrilla. (See *Water Spectrum, Winter 1976-77.*) They soon proved fonder of more desirable aquatic growth, and, more importantly, escaped and were helped into major river systems, lakes and even farm ponds—where their effect on existent biotas is not yet fully understood. Meanwhile, it is fervently hoped that the Amur, at least, will not spawn in the wild. The Tilapia does.

A probable overstocking of Amur, although under otherwise controlled conditions, in Lake Holden, near Orlando, caused a rapid consumption of the hydrilla that infested 90 percent of that body. The resultant sudden nutrient loading from the decaying plants initiated an algal growth explosion that turned the lake into a thick green soup.

Debating the relative merits of the Amur, however, is currently confined to academic circles. Nearly every state with a hydrilla problem—Arkansas is the lone exception—has outlawed the importation and stocking of

the Amur in its waters. (The Amur did solve Arkansas' aquatic weed problem, but it was a problem that did not include hydrilla.) A few states, such as Florida, stock Amur under stringently controlled conditions for test purposes (e.g. only females in Lake A, only males in Lake B.)

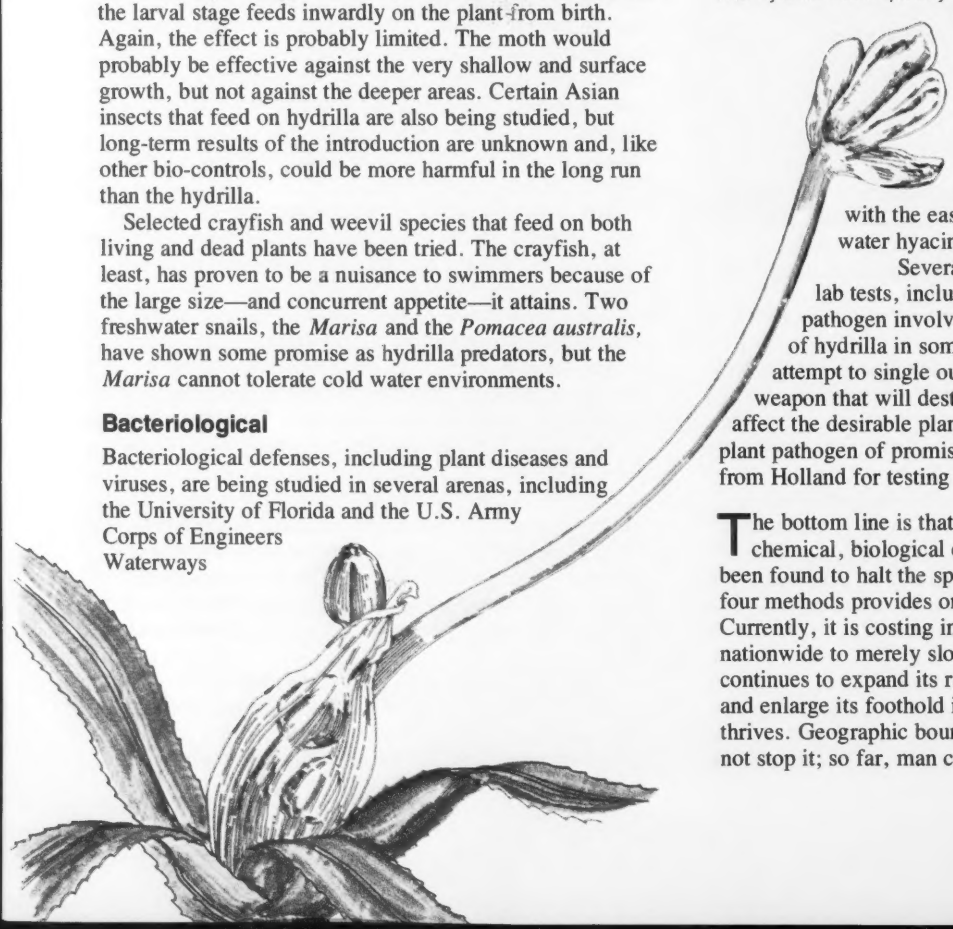
Numerous insects that are felt to be host-specific to the hydrilla, or nearly so, are being tested. A non-native species of moth that rates hydrilla very high on its menu has been introduced in Florida in the hope that it will provide sufficient stress to control the weed's expansion. The moth lays its eggs on the hydrilla near the surface, and the larval stage feeds inwardly on the plant from birth. Again, the effect is probably limited. The moth would probably be effective against the very shallow and surface growth, but not against the deeper areas. Certain Asian insects that feed on hydrilla are also being studied, but long-term results of the introduction are unknown and, like other bio-controls, could be more harmful in the long run than the hydrilla.

Selected crayfish and weevil species that feed on both living and dead plants have been tried. The crayfish, at least, has proven to be a nuisance to swimmers because of the large size—and concurrent appetite—it attains. Two freshwater snails, the *Marisa* and the *Pomacea australis,* have shown some promise as hydrilla predators, but the *Marisa* cannot tolerate cold water environments.

Bacteriological

Bacteriological defenses, including plant diseases and viruses, are being studied in several arenas, including the University of Florida and the U.S. Army Corps of Engineers Waterways Experiment Station in Vicksburg. (The 1899 Rivers and Harbor Act charges the Corps with maintaining the navigability of U.S. waterways. Hydrilla, along with the easier to control alligatorweed and water hyacinth, threatens this navigability.)

The hydrilla *mats quickly become so thick that the waterway they inhabit is a waterway in name only.*



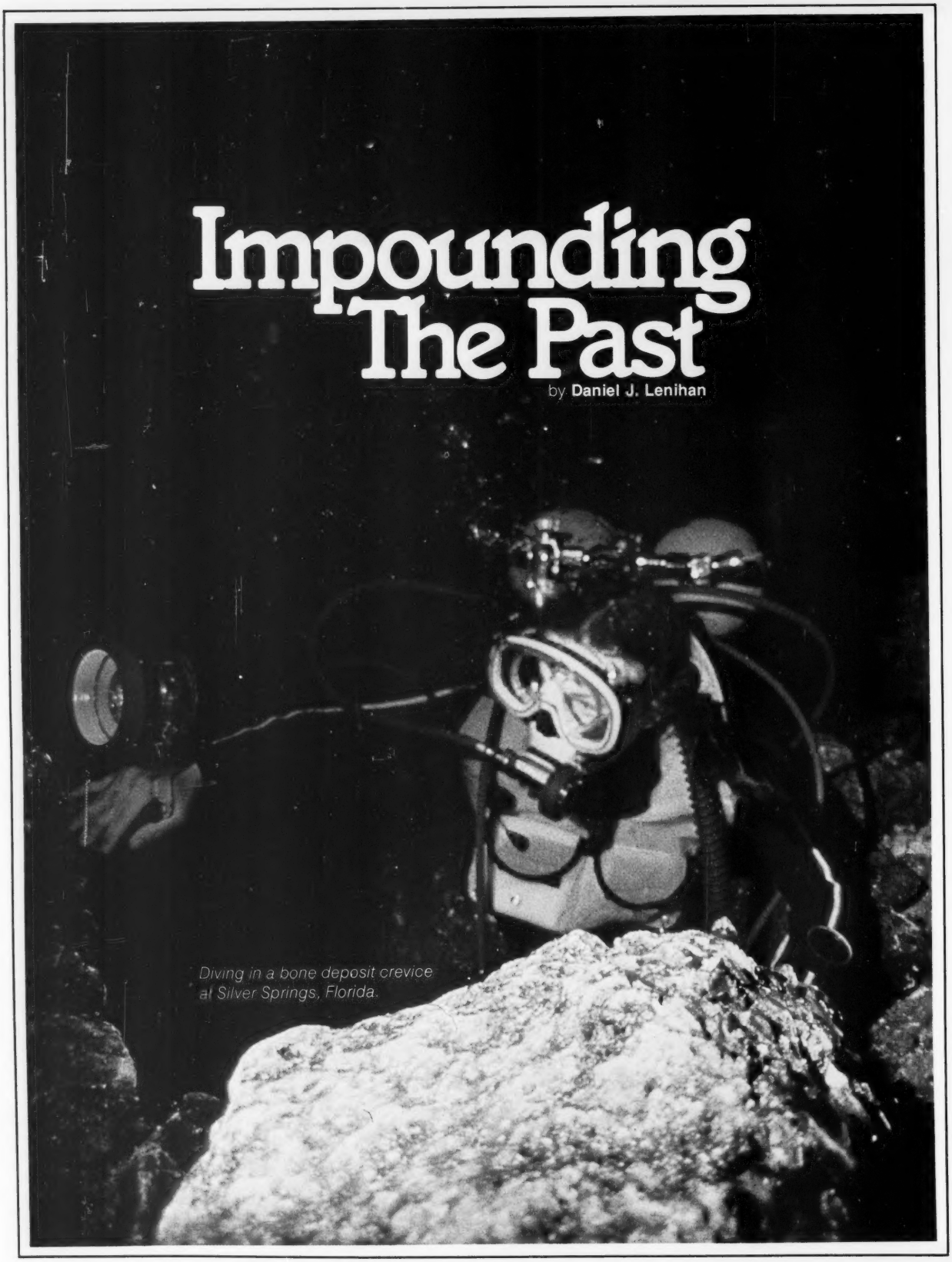
Several plant diseases are undergoing lab tests, including isolation of the single pathogen involved with the annual dieback of hydrilla in some Florida impoundments, in an attempt to single out and attack with a bacteriological weapon that will destroy the hydrilla—yet not adversely affect the desirable plant life in the host body of water. A plant pathogen of promise *(Fusarium)* has been imported from Holland for testing at the University of Florida.

The bottom line is that, as yet, no single mechanical, chemical, biological or bacteriological weapon has been found to halt the spread of hydrilla. Integration of the four methods provides only slightly better results. Currently, it is costing in excess of $100 million annually nationwide to merely slow down the onslaught. Hydrilla continues to expand its range, northward and westward, and enlarge its foothold in those areas where it already thrives. Geographic boundaries and temperature zones will not stop it; so far, man cannot stop it. ■

Close-up of hydrilla that has topped out in nine feet of water.

Impounding The Past

by **Daniel J. Lenihan**



Diving in a bone deposit crevice at Silver Springs, Florida.

During the 1970s, underwater archeology assumed an increasingly important role in Federal and state environmental programs. This was due in part to legislative mandates of the last decade which clarified the responsibility of land modification agencies to mitigate adverse impacts on cultural resources. An additional factor has been a burgeoning awareness on the part of the archeological profession that submerged sites do indeed comprise a legitimate and unique aspect of the cultural resource base.

The increased sensitivity on the part of both archeologists and water resource managers to the value and fragility of submerged sites has been enhanced by the recent, highly visible conflict over the disposition of certain Spanish shipwrecks in Florida. The treasure diving community has been extremely vocal in defending its "God-given right" to systematically vandalize our collective cultural heritage in the name of "free enterprise" and, for the most part, the courts have vindicated this position. The lead Federal agencies involved in the conflict have been the Bureau of Land Management, United States Geological Survey, and the Interagency Archeology Services—which is now a division of the newly formed Heritage Conservation and Recreation Service. Although the price has been great, this dispute has at least focused attention on an area of cultural resource management which has been greatly neglected in this country.

The question of historic shipwrecks on the continental shelf is, however, only one small part of the total submerged cultural resources management picture. In addition to the full gamut of inland sites, which we will discuss shortly, there are also prehistoric aboriginal sites on the inner continental shelf. For example, sea-level changes over the past 10,000 years—resulting from local shifts in the earth's crust and glaciation—have created a situation in which all remains of certain suspected maritime cultures are now isolated miles from any presently existing coastlines in the Gulf of Mexico. In other instances, it is felt that at least the maritime subsistence segment of certain known cultural horizons are now underwater. A Federal cultural resource management problem is now developing since these older sites and historic shipwrecks are being threatened by potential impacts from oil and gas lease sales and dredging operations.

In addition to the underwater archeological concerns on the inner and outer continental shelf, there is the problem of impacts on archeological sites in inland waterways. The Corps of Engineers has begun to confront the issue of riverine and estuarine dredging impacts through the initiation of cultural resources surveys in such places as the Tennessee-Tombigbee and the Yazoo Rivers.

One of the obvious types of archeological remains found in rivers, and subject to impact from channelization projects, is historic shipwrecks. There are also, however, significant portions of prehistoric and historic habitation areas which have been redeposited in rivers from wave generated cutbanks and other erosional processes that attend the natural meandering of rivers and streams. Although the strata arrangement of a riverine site is compromised, the horizontal displacement of the cultural remains is often minimal, and significant archeological value still remains in these sites even though slumping and redeposition have occurred. Significant paleontological sites have also been uncovered and made accessible to divers from the sediment displacing forces of rivers.

The Great Lakes comprise another fresh water environment that is extremely rich in submerged archeological sites and is in an area for which the Corps has certain management responsibilities. The Great Lakes contain, in addition to a limited number of sites of former human occupation, a wealth of colonial and 19th Century shipwrecks. These resources comprise a data bank on the maritime history of the "Inland Seas" that is unequaled in any documentary or land-based resource. This is especially important when we consider that blind spots still exist in our knowledge of our own maritime past that are sometimes greater than those existing in our knowledge of classical marine architecture before the time of Christ!

Another unique underwater environment that has revealed a surprising amount of remains of paleontological and archeological value are the submerged caves and sinkholes associated with Karst (limestone bedrock) areas. These underground drainages were often used by prehistoric peoples at those points where the water reached the surface in the form of resurgences or springs. In the flooded caves of the Florida karst, the lowered piezometric (water pressure table) levels, which resulted from the lower sea level at the end of the last ice age, created a situation where what were once human activity areas are now under a water column. Preservation of organic cultural materials in this environment has been extraordinarily good. In one case in Florida, human brain material survived in a cranium that is believed to be several thousand years old. Usually, the only Federal impact that can affect springs results from inundation by a lake as a result of dam construction, e.g. Goodenough Springs in Amistad Reservoir, Texas. Even the nearby construction of a water impoundment area may result in changes in flow and water quality in karst features since placing the huge weight of a water column over the recharge area of springs can greatly alter their nature.

The author is unaware of an instance in which a reservoir construction agency has taken steps to investigate possible impacts to cultural resources in submerged karst features as a result of its construction activities. There has been some sensitivity to possible impacts on dry caves, however, as is witnessed by the pre-impoundment studies at New Melones Reservoir funded by the Corps of Engineers.

Primary forms of Federal impact on cultural remains in all of these natural water bodies include dredging and construction of underwater utility platforms and marinas (the latter often conducted by the private sector with Federal permits). To the degree that legal compliance is achieved for these activities, the work is usually performed by outside institutional contractors. Unfortunately, there are very few such contractors who have the knowledge and expertise to deal with submerged archeological sites and fewer agency officials who would be able to judge the competence of such work when it is performed. Assistance from a state archeologist's office is also unlikely since only a handful of state offices have underwater archeological expertise. As

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more and more attention is paid to submerged resources, a correspondingly greater number of trained archeologists with an underwater orientation will be in demand. Apparently, the Savannah District of the Corps of Engineers, along with interested individuals in other southeast districts, is taking steps to develop an in-house underwater archeological capability.

The National Reservoir Inundation Study

In addition to all the potential concerns for underwater archeology by the Federal government in the above listed natural water bodies, there is the question of the effects of inundation through reservoir construction on archeological sites. The remainder of this article will deal with that question since it presents a unique example of what can be done through interagency cooperation to confront submerged cultural resource management problems.

The need for a reservoir inundation study of some sort was first articulated by Donald Jewell (University of California) in the early 1960s, but its final realization as an operational multi-agency funded entity did not take place until the latter part of 1975. Representatives of the Corps of Engineers, the Bureau of Reclamation, the Soil Conservation Service, and the National Park Service met and agreed to share funding for a research project which would strive to assess just what were

Silt buildups after impoundment often obscure sites of cultural remains.

Adobe brick samples are observed beneath the waters of Amistad Reservoir, Texas.

Artifacts are photographed in place in Round Springs Grotto, Missouri.

Bureau of Reclamation and National Park Service divers discuss safety procedures prior to a reconnaissance in Arizona's Lake Havasu.

the effects of building a dam and impounding water over archeological resources in and around the resulting reservoir, and what could best be done to mitigate any adverse effects.

A simple minded and obvious enough question one might think. It should be noted, however, that millions have already been spent on "salvaging" archeological sites from the impact zones of impoundment areas, and nobody had ever really seriously addressed the issue of what was and wasn't being harmed in those sites. The first organized, meaningful attempt to confront this issue came not from the archeological profession in the institutions which had been contracted for years to salvage sites in reservoirs, but primarily from the archeologists and environmentalists in the Federal agencies themselves who were placed in the position of monitoring the activities of the contracting archeologists. The National Park Service was chosen as the lead agency in the study since, although it has reservoir management responsibilities in its recreation areas which would benefit from the knowledge to be gained from the study, the Service builds no reservoirs itself and would have no prejudice as to the outcome of the research. Additionally, the Southwest Region of the Service had an existing underwater archeological capability which could be utilized for the study.

The Inundation Study research design addresses two interrelated problems: What are the effects of inundation on archeological sites, and, given a predicted impact, what are the alternatives open to cultural resource managers to mitigate these adverse effects? The study also has attempted to articulate any beneficial effects of inundation on the resource. In certain situations—such as when particular types of sites are quickly flooded and then subjected to uninterrupted deep inundation with no wet/dry cycles—the long term effects of inundation might actually be construed as beneficial from a preservation standpoint. There is the problem of reduced accessibility to researchers.

Thus far, however, the primary effects have been determined to be essentially negative, with the initial flooding event and subsequent drawdown cycles causing the worst damage. The Inundation Study core team has pinpointed several categories of impacts, the inundation/drawdown type being classified under "Mechanical Impacts." These are direct modifications of the horizontal and vertical integrity of a site from factors such wave action, slumping of banks composed of cultural deposits, and wind deflation over sites denuded of vegetation after waters have receded to a lower pool level.

Inundation Study archeologists are also investigating impacts on common cultural materials (e.g. ceramics, stone, bone, etc.) as a result of immersion in fresh water. This is done through visiting actual sites in reservoirs that had been partially dug when they were dry, and excavating similar materials from them now that they are covered by a water column. It often entails complicated research diving techniques to retrieve data comparable to that retrieved when the sites were dry. For this reason, all members of the Inundation Study core team must maintain a high degree of competence in research diving procedures besides being professional archeologists.

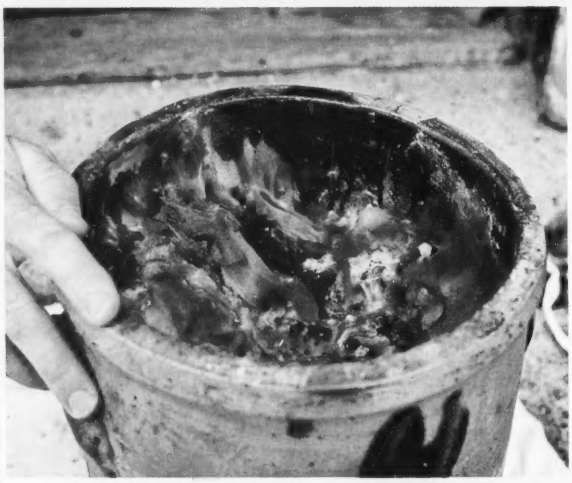
To gain additional insights into the chemical and microbiological impacts of immersion on cultural materials, the core team has initiated a series of laboratory experiments which are being carried out in cooperation with the University of New Mexico, Virginia Polytechnic Institute and Texas A & M. Tightly controlled studies of the effects of immersion on pollen (used by archeologists to gain an understanding of past environmental conditions) and various dating techniques such as radiocarbon, obsidian hydration etc., are also being addressed in this laboratory phase of the research. Artifacts are placed in buckets of water that have carefully controlled chemical environments, and where the amount of certain chemicals is greatly increased in comparison to what would be found in a real reservoir. The impacts of these chemicals on the artifacts in question are thereby isolated and greatly accelerated.

Using similar procedures for selected microorganisms, Inundation Study researchers are developing a predictive model which can be used by resource managers to anticipate what will happen to different archeological values in a particular reservoir once the nature of the water chemistry is known. In this way, the responsible agency and the archeological advisory bodies concerned may make intelligent

decisions as to where mitigative efforts should be directed for any particular reservoir.

Mitigation may consist of actually doing pre-impoundment research on the most vulnerable aspects of a site, or, in other cases, opting to take measures to physically protect the site from the worst anticipated impacts of inundation. This last alternative is in line with the growing "conservation ethic" in the American archeological community. Reacting to impending inundation only by "salvaging" as many sites as possible through excavation has drawn increasing criticism from both Federal and institutional cultural resource specialists. "Salvaging" a site also destroys it for any future research efforts when the archeological techniques will probably be vastly improved.

The answer lies in making reservoir-specific decisions as to how to deal with inundation, based on the regional resource picture and on the knowledge of what specific types of sites and values in these sites will be impacted by inundation. The Inundation Study is geared to provide a body of much needed data on the latter.



This crock of cheese was recovered from the Alvin Clark, *after the ship had been underwater in Lake Michigan for more than a 100 years.*

Core team archeologists have also focused attention on an associated problem of reservoir construction; the impacts that develop outside of the flood pools from increased accessibility to visitor use. In many cases, sites have been protected from vandalism simply by being located in remote areas where the only visitors might be an occasional backpacker who is usually comparatively respectful of the environment or he wouldn't be backpacking. Some of the tremendous devastation to prehistoric sites in reservoir recreation areas, especially in southwestern canyon country, has come from accessibility of the resource to anyone with a motor boat and six pack of beer.

Additional approaches being used to confront the inundation question include the construction of an entire artificial archeological site by the Arkansas Archeological Survey under contract to the Inundation Study. The Arkansas archeologists used actual, local prehistoric artifacts which they carefully tested before reburying them. Hearths were made by burning fires in the soil matrix of the site (to check effect

As water recedes during drawdown, banks deflate, terraces are formed by wave action, wind erosion removes vegetative cover, and archeological sites are destroyed.

on archeomagnetic dating) and plexiglass sheets were placed against walls or profiles of the site trenches on which the layers composing the existing strata were traced. This "site" has been covered by a water column as the conservation pool in Blue Mountain Lake was re-established. Core team researchers will dive back on the site and remove the artifacts this summer, and analyze for trends towards deterioration.

Besides working in reservoirs and laboratories, the Inundation Study core team has been undertaking investigation in two other aqueous environments: Great Lakes shipwrecks and submerged caves.

A shipwreck in a fresh water body such as a river or natural lake is subjected to most of the same prevention/deterioration factors that are found in reservoirs. In addition, the shipwreck is by nature a "time capsule" which has been deposited at a point in time which in some cases can be traced to not only a particular year, but the hour of the day! The ship, having been composed of wood and metals and carrying a full complement of ceramics, organic materials, etc., in essence comprises a living laboratory for assessing impacts of inundation on certain classes of material culture.

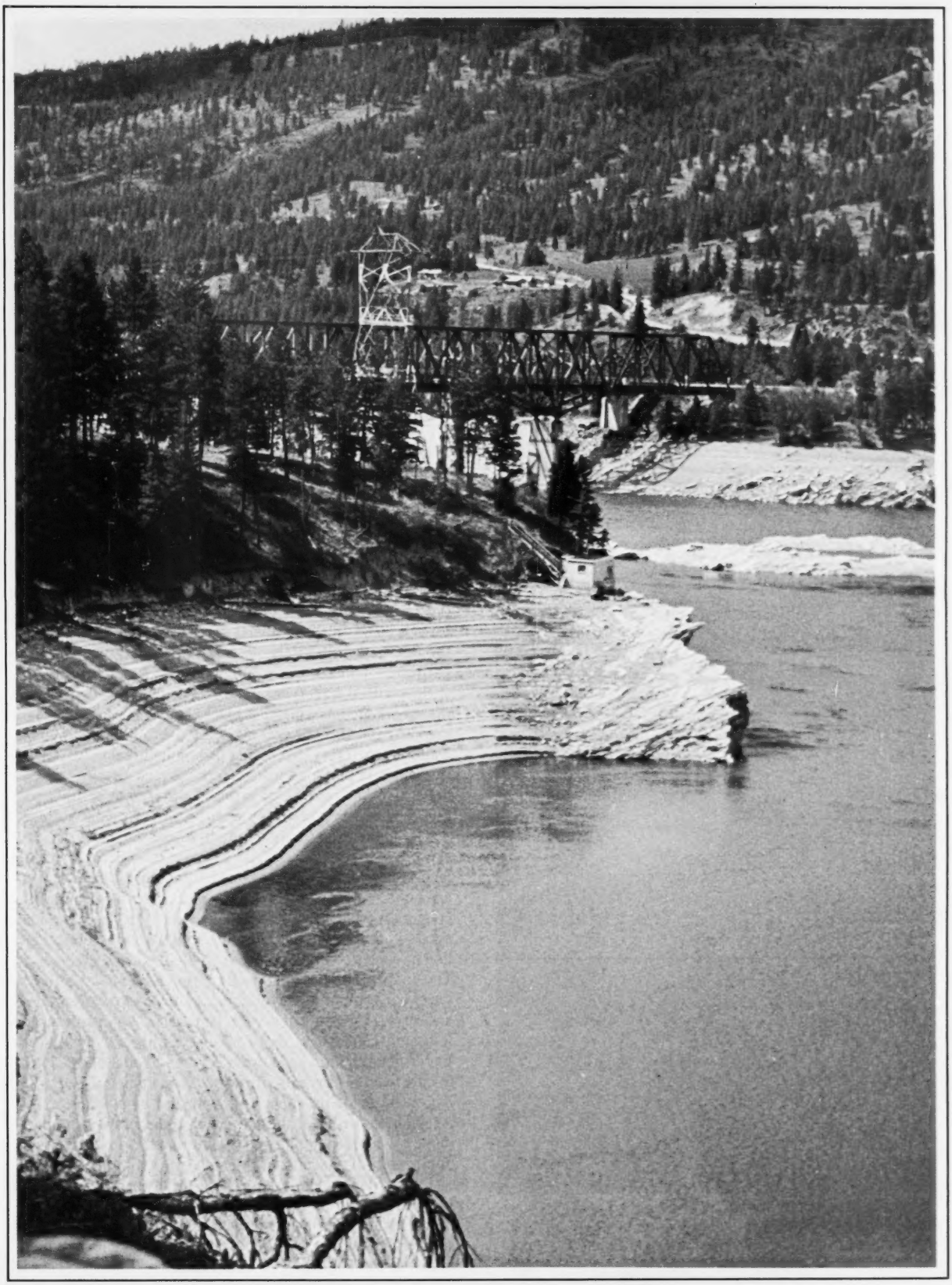
The springs and submerged caves of karst areas are also of interest to core team researchers. The ground water features, for reasons mentioned earlier in this article, often contain archeological remains which date back thousands of years. Retrieving materials from these submerged caves provides data on long-term effects of inundation in fresh water. It is interesting to note that preliminary research performed in springs in Missouri revealed that the water chemistry of certain springs was almost identical in chemical composition to the mean chemical composite of reservoirs in the United States. This factor increases their viability as potential indicators of the effects of long term inundation in reservoirs.

Preliminary Research Results

Results of the Inundation Study thus far indicate that the mechanical impacts occurring from the initial raising of a pool, attended by a subsequent drawdown, present some of the greatest problems to archeological sites. The drawdown is particularly devastating since the high energy land/water interface is moving down over soils that are already saturated and have lost their vegetative mantle.

There is also a tendency for the soil chemistry values in a site, which are used by archeologists to understand how different parts of a site are utilized, to be homogenized. Other significant impacts have been noted on rock art, pollen remains and the very materials from which prehistoric structures are created—including sandstone slabs and certain low grade granites.

Mitigative efforts that have been tried or evaluated, in addition to the standard response of salvage, include the building of cofferdams around certain sites, artificially creating selective siltation over sites, instigating growth of certain grasses over sites before the water level passes over the area, and the use of energy dissipating devices such as breakwaters. In all cases, these protective approaches should be combined with selective pre-inundation data retrieval of the most easily damaged archeological data categories.



These representative types of artifacts will be inundated under laboratory conditions to determine the effects of impoundment in known chemical environments.

Pottery fragments are emplaced and marked at the Blue Mountain site prior to inundation. Researchers will analyze their state of preservation, movement by wave action, and burial by silt following impoundment.

In Glen Canyon National Recreational Area, Inundation Study archeologists, assisted by a National Park Service ruins stabilization expert, have experimentally repointed the joints in a prehistoric masonry structure about to be inundated. Various grouts, including epoxy bases, were used to determine which is the most efficient. A submerged prehistoric wall was also stabilized in the same manner, probably the first time such a delicate preservation task has ever been performed under a water column.

Specialized underwater equipment used by the team in their work includes an underwater plane table and alidade for mapping, air lifts for sucking away overburden, and underwater video. The video taping technique is especially effective since it provides instant feedback on results, can see better than the naked eye in turbid water, and permits nondiving scientists to observe and direct work from the surface.

The Inundation Study is a unique endeavor not only because it bridges the artificial gap that often exists between land archeological concerns and submerged resource management, but because it sets a precedent for interagency cooperation. The fact that four Federal agencies have managed to jointly fund and interrelate with a minimum of friction on such a complex research problem is a heartening sign. The cooperation has gone well beyond the initial funding to the equally important level of day to day exchanges of ideas and data. The Bureau of Reclamation's Engineering and Research Center and the Corps of Engineers' Waterways Experiment Station have provided a great deal of assistance to core team researchers. Besides the fact that this is gratifying to those of us concerned with the conducting of the research, it also saves the taxpayer a considerable amount of money when Federal agencies pool their resources to avoid duplication of specialized research efforts.

This writer sincerely hopes that the precedent set by the Inundation Study for cooperative Federal research for management purposes is extended to some of the other areas of submerged cultural resource management which were mentioned in the beginning of this article. ■

Events, Deeds & Deliber-ations

MAPS To Aid Planners

by **Thomas M. Walski**

A new tool has been developed to assist engineers and planners in formulating and evaluating alternative water supply and wastewater management plans.

MAPS (Methodology for Areawide Planning Studies), is a computer-assisted program devised by the Corp of Engineers' Waterways Experiment Station (WES) that has already been field-proven in both the Salinas-Monterey and Nashville Urban Studies arena. It provides an early assessment of the feasibility of alternatives and a preliminary analysis of costs.

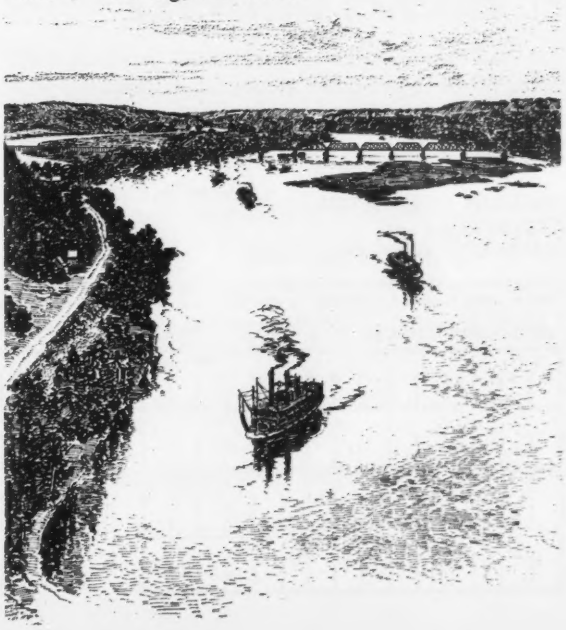
In both studies, the WES study team using MAPS developed a set of alternative water supply plans. The starting point for each study was the usual information available at the start of most water supply studies: streamflow records, population projections, description of existing system, and the results of previous planning studies. With this data and the MAPS program, the study team not only identified plans which met future water needs, but also identified the major facilities required and calculated the equivalent annual cost, including capital and operation and maintenance costs, for these facilities.

The studies were divided into two phases. In the first, the hydrology of the study area streams and flows in transmission and treatment facilities were simulated in different years in the planning period. There were two types of simulations: steady-state simulations which were used to analyze the adequacy of treatment and transmission facilities and diversions from unregulated streams, and unsteady-state simulations which were required to assess reservoir storage and streamflow regulation.

With the facilities identified, the study team then performed a more detailed analysis of each. Preliminary designs consisted of sizing of the facilities (e.g., diameter of pipes, depth of wells, degree of treatment, horsepower of pumping stations). Capital and operation and maintenance (with power costs specified separately) were calculated using cost equations calibrated for each study area. These costs were then amortized to yield average annual cost through the study period.

While thus far the MAPS program has been applied to water supply for large study areas, this is not the only application that the MAPS study team sees for the program. It is readily applicable to wastewater management studies and water supply studies for areas as large as a state or as small as a Corps recreation area at a reservoir. It can also be applied to military bases with water supply, wastewater or drainage problems. Future development on the program will include improved estimating of nonpoint runoff and assessment of management practices to control runoff.

More information on MAPS can be obtained from the Environmental Laboratory, USAE Waterways Experiment Station, Vicksburg, MS 39180. ■



Mr. Walski is a sanitary engineer with the Environmental Laboratory, Waterways Experiment Station, U.S. Army Corps of Engineers in Vicksburg, Mississippi.

Energy Use Cuts Possible

With energy supplies in oil and gas already past their peak in the United States, basic boundaries will have to be honored in the next quarter century in the quality and quantity of energy use, a recent Michigan State University conference on clothing and energy was told.

Herman Koenig, director of the MSU Center for Environmental Quality, told the conference that a substantial amount of energy will be needed alone to provide the hardware necessary for the changes in lifestyle which will be required as conventional supplies continue to shrink.

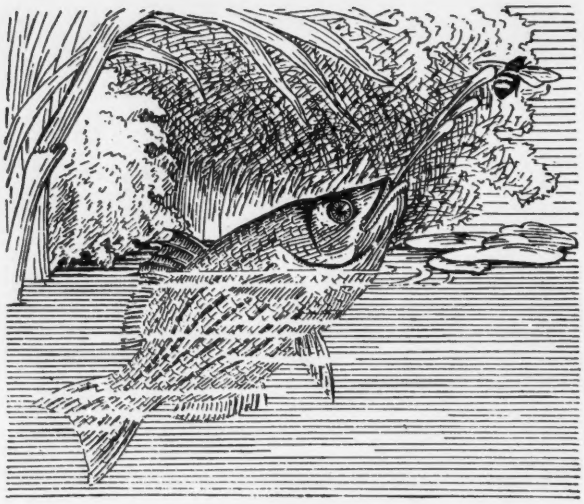
He cited the example of "district heating systems" in residential areas—including suburbia—in contrast to the single-home system of heating now in use and accounting for one-fourth of the energy consumption in the nation.

The MSU professor suggested that Americans could cut their energy use one-third without any hardship. "Otherwise," he said, "it is not clear that our grandchildren will have enough resources to support us in our old age." ■

Recreational Fishing Survey Contract Awarded

The National Oceanic and Atmospheric Administration has awarded contracts totaling $1.3 million to Human Sciences Research, Inc., McLean, Va., and Clapp and Mayne, Inc., San Juan, Puerto Rico, to collect data on the fish catch by marine recreational anglers. The survey is being conducted for the National Marine Fisheries Service.

The recreational fishery statistical survey will be done on the Atlantic and Gulf coasts, Hawaii, Guam, American Samoa, Alaska, Puerto Rico, and the Virgin Islands. The



results of the survey, to be conducted between November 1, 1978, and October 31, 1979, will be available in February 1980.

The survey will provide estimates of participation, catch, and effort by marine recreational anglers for each geographical region and state in the survey. Included will be information on finfish and selected shellfish by species, by state or region; the number of marine anglers; number and length of fishing trips; number of days spent fishing; total catch by weight and numbers; method of fishing used and what the anglers did with their catch.

The information obtained during the survey will be used in the development of fishery management plans by the Regional Fishery Management Councils. ■

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Changes of Command

Major General Louis W. Prentiss has been named Ohio River Division Engineer succeeding Major General E. R. Heiberg III. Prentiss is a U.S. Military Academy graduate with a master's degree in civil engineering from Princeton University.

Colonel Clyde A. Selleck is the new Missouri River Division Engineer with headquarters at Omaha, Nebraska. He succeeds Brigadier General William E. Read, whose new assignment is Assistant Chief of Engineers, Office, Chief of Engineers. A graduate of the U.S. Military Academy, Selleck also received his master of science in civil engineering from Princeton University.

Colonel James H. Higman became District Engineer at Huntington, West Virginia, effective February 26. He succeeds Colonel George A. Bicher, who will retire. Higman was the Chief, Installations Planning Division, Office of the Assistant Chief of Engineers.

Brigadier General Walter O. Bachus (USA Ret.) has been appointed Executive Director of the Society of American Military Engineers, replacing Brigadier General William C. Hall (USA Ret.) who retired in October. ■

Bookshelf

CATALYST For Environmental Quality magazine brings to its readers reports and views of top specialists and authorities on all aspects of the outdoor environment, and efforts to improve it. Topics covered range from "Ecological houses of the future" to new ways to solve today's energy, noise, air, solid waste and water problems.

Publisher Nelson Buhler, a New York attorney, says CATALYST "aims to help restore a quality environment and prevent new damage. There are now available to man more answers to environmental problems than there are users of those answers . . . We try to serve as a catalytic influence in getting relevant, environmentally-oriented knowledge, research and skills put to use". Editor: Laura E. Freed. Manuscripts and correspondence should be addressed to: PO Box 1144, FDR Station, New York, NY 10022. (212) 753-2769. ■

In recent years the exploration of ocean space and the exploitation of its vast mineral, energy, and living resources have become vitally important to the international community. Yet no single publication has systematically collected and interpreted information on scientific and technical progress, advances in international law and commercial regulation, shifting naval organizations and power structures, and other developments affecting the future of the oceans.

Ocean Yearbook, a new, annual publication, is intended to fill that gap—providing the authoritative data and broad surveys necessary for an understanding of the rapidly evolving economic, political, scientific, and social uses of ocean space. It consists of twenty-two essays collected under such categories as living and nonliving resources, transportation and communications, marine science and technology, environment, and military activities.

The book is edited by Elisabeth Mann Borghese and Norton Ginsburg. It is available for $25.00 from the University of Chicago Press, 11030 South Langley Avenue, Chicago, IL60628. ■

The **National Wetlands Newsletter** is a new, monthly publication containing up to date information on scientific research, developments in local, state and Federal programs and activities, private efforts, legislation, litigation, literature, and conferences relating to inland and coastal wetlands and floodplains.

The National Wetlands Newsletter is a project of the Environmental Law Institute, Suite 600, 1346 Connecticut Avenue, N.W., Washington, D.C. 20036. Subscriptions are $25.00 for 12 issues. ■

The **Sourcebook on the Environment,** produced in conjunction with the Association of American Geographers, provides a much-needed, objective, and comprehensive guide to environmental studies. Twenty-six specialists have compiled and critically annotated commentaries on the sources treating a broad spectrum of crucial issues, ranging from resource scarcity to the environmental impact of urbanization.

The book is edited by Kenneth A. Hammond, George Macinko, and Wilma B. Fairchild. It is available for $22.00 from the University of Chicago Press. ■

Coming Events

North American Lake Management Conference, Michigan State University, East Lansing, Mich., April 16-18, 1979.

American Geophysical Union 1979 Spring Meeting at University of Kansas, Lawrence, Kans., May.

22nd Conference, Great Lakes—79, International Association for Great Lakes Research at Rochester, N.Y., May 1-3.

1979 Pecora Symposium sponsored by American Water Resources Association at Sioux Falls, S. Dak., June 11-14.

National Workshop on Mitigating Losses of Fish and Wildlife Habitats, Fort Collins, Colo., July 16-20.

International Symposium on Drought at New Delhi, India, September 2-7.

15th American Water Resources Conference at Las Vegas, Nev., September 24-28. ■

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Historically, fish and wildlife were viewed as a limitless commodity that received little protection in the grand scheme of resource development. The future is brighter. *See "Habitat Evaluation" on Page 26.* U.S. Fish & Wildlife Service photo by Cathy Short

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